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The bone and ivory industries of the Aegean Bronze Age : a technological study

THE BONE AND IVORY INDUSTRIES OF THE AEGEAN BRONZE AGE : A TECHNOLOGICAL STUDY

Volume I - TEXT

Thesis submitted for the degree of Doctor of Philosophy in the University of Bristol.

Autumn, 1981

O.H. Krzyszkowska

STATEMENT OF ORIGINALITY

The work presented in this thesis on "The Bone and Ivory Industries of the Aegean Bronze Age: a Technological Study" is entirely my own. Full credit is given in the Acknowledgements and Footnotes for suggestions or advice offered by others.

O.H. Krzyszkowska

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Autumn, 1981

(O.H. Krzyszkowska)

The Bone and Ivory Industries of the Aegean Bronze Age: a Technological Study.

Synopsis

This study is concerned with the use of bone, ivory, and the related materials boar's tusk and antler during the bronze age in the Aegean. It presents published and unpublished material from archaeological sites in four main regions within the Aegean: the Mainland, Crete, the Cyclades, and the North-east Aegean. Objects ranging from bone tools to fine ivory carvings are considered.

The approach to this study is technological rather than art historical. Emphasis is placed on the question of selection of particular materials for given end-products, influenced by factors such as suitability and availability of the raw material. Methods of correctly identifying the materials in worked state are also discussed. This is particularly valuable in the case of ivory, the presence of which may have significant implications for economic developments.

Attention is given to the problems of determining manufacture methods and discussion centres on the various types of evidence available for this purpose. These include stages in manufacture as revealed from rough-outs and wastes, finished objects, tool marks, workshop and comparative material. The difficulties of determining function, especially for bone tools are considered as are various systems of classification for worked bone used in the Aegean and elsewhere.

A typology for objects of bone and related materials is presented. This is designed for use with the Catalogue of objects (Volume II, Appendix I).

The bone and ivory industries of selected sites, (Thermi, Lerna, Ayia Irini, Royal Road, Knossos; and Citadel House, Mycenae) are considered. The study concludes with a summary of the evidence for these industries at regional level.

The Catalogue, Material of Unknown Provenance, Catalogue of the Lebena seals and Bone typologies for Lerna and Ayia Irini are offered as Appendices (Volume II). Tables, figures and plates illustrating the unpublished material presented in the Catalogue form Volume III.

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ACKNOWLEDGEMENTS

In the course of this study I have received assistance in many fashions from numerous people. Whether it was a case of financial assistance, the offer of accommodation, the unravelling of a bureaucratic tangle or permission to study important groups of finds, my gratitude is equally deep. To name all those people who have helped would be impossible.

Excavators and colleagues both in Greece and elsewhere who have allowed me to use their unpublished material and who have offered advice are acknowledged more fully in the notes to this study. Here I should like to mention my thanks to Professor Keith Branigan, my first supervisor; Professor Peter Warren who has seen me through the more recent stages of study, and Professor J.L. Caskey for all his help and encouragement as well as his generosity regarding the material from Lerna and A. Irini. To the Curator, Professor Anthony Snodgrass and the staff of the Museum of Classical Archaeology go my most sincere thanks and gratitude.

People who are not directly involved in the field of Aegean archaeology have also played an important part in facilitating this study. In Cambridge I should like to thank my typist, Mrs. Ann Hill, especially for her valiant efforts with the Catalogue. I am also grateful to Miss E.M.S. Duignan and Miss C.A. Schofield for help with photographic equipment and for providing me with a second home near Cambridge. My former College, New Hall, and its fellows, especially Miss E.D. Rawson and Dr. C.J. Kerslake have also provided me with hospitality at several difficult points in my career.

Finally there are three individuals to whom I am deeply indebted and without whose assistance this study would never have been completed: my mother, Mrs. O.L. Krzyszkowska; Miss E.D. Rawson, and Major A.B. Vickery.

Note on Catalogue Numbers

In the text and plates catalogue numbers are used to refer to items found in Appendix I: The Catalogue (Volume II). They are to be read as follows: 11c 36

11 = Type 11 (Pointed objects, Pins)

c = sub-type c (decorated heads)

: 36 = number 36 - a bone hammer-headed pin from Lerna.

The letters NC (e.g., 11: NC) indicate that the piece is not given full catalogue treatment, although it may be illustrated. Other non-catalogued items include objects of unknown provenance from Tiryns (Appendix IIb).

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ABBREVIATIONS OF REFERENCES

The following abbreviations pertain to references cited in the text, footnotes (Volume I), and Catalogue (Volume II).

AAA	Athens Annals of Archaeology
Actes Rome	Atti e Memorie del Primo Congresso Internationale di Micenologia (Rome, 1967)
AD	Archaiologikon Deltion
Agora XIII	S.A. Immerwahr The Athenian Agora XIII, the neolithic and bronze ages, (Princeton, 1971)
AJA	American Journal of Archaeology
ANM	Athens National Museum (inventory number)
Annuario	Annuario della Scuola Archaeologica di Atene
AR	Archaeological Reports
Arch-Anz	Archäologischer Anzeiger
Asea	E.J. Holmberg, The Swedish Excavations at Asea in Arcadia (Göteborg, 1944)
Asine	O.Frödin and A.W. Perrson, Asine (Result of the Swedish Excavations, 1922-30) (Stockholm, 1938)
Ath. Mitt.	Mitteilungen des deutschen archäologischen Instituts, Athenische Abteilung
BASOR	Bulletin of the American School of Oriental Research (in Jerusalem)
BCH	Bulletin de Correspondence Hellenique
Blegen I-IV	C.W. Blegen, J.L. Caskey, et al., Troy Vol.I Princeton University Press, 1950), Vol.II (1951), Vol.III (1953), Vol.IV (1958)
Brea I-II	L. Bernabo-Brea, Poliochni: Cittá Preistorica nell' isola di Lemnos Vol.I (Roma, 1964), Vol.II (Roma, 1976)
BSA	Annual of the British School at Athens

CAH II.1	The Cambridge Ancient History Vol.II Pt.1. History of the Middle East and Aegean Region c.1800-1380 B.C. ed. I.S. Edwards, G.J. Gadd, et al. (Cambridge, 1973)
Centre Politique I	H. et M. van Effenterre, Le Centre Politique I, L'Agora (1960-66) (Études Crétoises XVII) (Paris, 1969)
Centre Politique II	Marie-Claire Amouretti, Le Centre Politique II, La Crypte Hypostyle (1957-62) (Études Cretoises XVIII) (Paris, 1970)
Circle B	G.E. Mylonas, O Tafikos Kyklos B ton Mykinon (Athens, 1973)
C (M)	Candia (Iraklion) Museum (inventory numbers). Older publications.
CM	Chora Museum Messenia (inventory numbers)
CMS	Corpus der minoischen und mykenischen Siegel. Band 1 (Athens) ed. Agnes Sakellariou (Berlin, 1964); Band II.1 (Iraklion: Die Siegel der Vorpalastzeit) ed. N. Platon (Berlin, 1969); Band II.2 (Iraklion: Die Siegel der Altpalastzeit) ed. N. Platon et al., (Berlin, 1977); Band IV (Iraklion: Sammlung Metaxas) ed. J.A. Sakellarakis and V.E.G. Kenna (Berlin, 1969)
Colloque I	Premier Colloque internationale sur l'industrie de l'os dans la préhistoire ed. H. Camps-Fabrer (Éditions de L'université de Provence, 1974)
Colloque II	Methodologie appliquée à l'industrie de l'os préhistorique (Colloques internationaux du C.N.R.S. no. 568) (Paris, 1977)
CTD	P. Åström et al. The Cuirass Tomb and other Finds from Dendra (SIMA 4) (Göteborg, 1972)
Deshayes	J. Deshayes, Argos, les fouilles de la Deiras (Études péloponnesiennes IV) (Paris, 1966)
Doumas, Burial Habits	Ch. Doumas, Early Bronze Age Burial Habits in the Cyclades (SIMA 48) (Göteborg, 1977)
DS	Ch. Tsountas, Ai Proistorikai Akropoleis Dimeniou Kai Sesklou (Athens, 1908)

Eph. Arch	Ephimeris Archaiologiki
Ergon	To Ergon tis Archaiologikis Etaireias
Et. Cret.	Études Crétoises
Eutresis I	H. Goldman, Excavations at Eutresis in Boeotia (Cambridge, Mass., 1931)
Eutresis II	E. and J.L. Caskey, 'The Earliest Settlements at Eutresis, Supplementary Excavations, 1958,' Hesperia 29 (1960) pp.126-67
Hesp.	Hesperia
HM	Iraklion Museum (inventory numbers)
Hood, Arts	S. Hood, The Arts in Prehistoric Greece (Harmondsworth, 1978)
Iv.Myc.	J.-C. Poursat Les ivoires mycéniens (Paris, 1977)
JHS	Journal of Hellenic Studies
Kadmeia I	S. Symeonoglou, Kadmeia I (SIMA 35) (Göteburg, 1973)
Karo	G. Karo, Die Schachtgräber von Mykenai (Munich, 1930-1933)
Katsambas	St. Alexiou, Isterominoikoi tafoi limenos Knosou (Katsamba) (Athens, 1967)
Kirrha	L. Dor, J. Jannoray, H. and M. van Effenterre, Kirrha, Étude de préhistoire phocidienne (Paris, 1960)
Korakou	C.W. Blegen, Korakou, a Prehistoric Settlement near Corinth (Boston and New York, 1921)
Kosmopoulos	L.W. Kosmopoulos, The Prehistoric Inhabitation of Corinth (Munich, 1948)
Lamb	Excavations at Thermi in Lesbos (Cambridge, 1936)
Levi: Festos	D. Levi, Festòs e la civiltà minoica (Rome, 1976)
Maisons I	P. Demargne et H. Gallet de Santerre, Explorations des maisons et quartiers d'habitations (1921-48) I (Études Crétoises IX) (Paris, 1970)

Maisons II	J. Deshayes et A. Dessenne, Explorations des maisons et quartiers d'habitations (1948-54) II (Études Crétoises XI) (Paris,1959)
Maisons III	O. Pelon, Explorations des maisons et quartiers d'habitations (1963-66) III (Études Crétoises XVI) (Paris, 1970)
Maisons IV	H. et M. van Effenterre, Explorations des maisons et quartiers d'habitations (1956-60) IV (Études Crétoises XXII) (Paris, 1976)
Menidi	H.G. Lolling Das Kuppelgrab bei Menidi (Athens, 1880)
Met.Mus.St.	Metropolitan Museum Studies
M.Mal	Musée du Mallia (inventory numbers)
MM	Mytilene Museum (inventory numbers)
Mochlos	R.B. Seager Explorations on the island of Mochlos (Boston and New York, 1912)
Mon.Ant.	Monumenti Antichi
Myrtos	P.M. Warren, Myrtos, an Early Bronze Age Settlement in Crete (Oxford, 1972)
Nécropoles I	P. Demargne, Explorations des Nécropoles (1921-23) I, (Études Crétoises VII) (Paris, 1945)
Nécropoles II	Explorations des Nécropoles (1915-28) II (Études Crétoises XIII) ed. H. et M. Effenterre (Paris, 1963)
NTD	A.W. Perrson, The New Tombs at Dendra near Midea (Lund, 1942)
Papadopoulos Mycenaean Achaea	Th. J. Papadopoulos, Mycenaean Achaea (SIMA 55) (Göteborg, 1979)
Perati	S. Iakovidis, Perati: To nekrotafeion (Athens, 1969)
Pernier: Festòs	L. Pernier and L. Banti, Il Palazzo minoico di Festòs I-II (Rome, 1935, 1951)
Phylakopi	T.D. Atkinson, R.C. Bosanquet et al., Excavations at Phylakopi in Melos (JHS supp. paper no.4, 1904)
PM	A.J. Evans, The Palace of Minos at Knossos I-IV (London, 1921-36).

PN	C.W. Blegen, et al., The Palace of Nestor in Western Messenia: Vol. I The Buildings and their Contents (Princeton University Press, 1966); Vol.III The Akropolis and Lower Town (1973)
Poursat	J.-C. Poursat, Catalogue des ivoires mycéniens du Musee Nationale d'Athenes (Paris, 1977).
Praktika	Praktika tis en Athinais Archaiologikis Etaireias
Pre.Mac.	W.A. Heurtley, Prehistoric Macedonia (Cambridge, 1939)
Proc.Konink. Akad.	Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen (Series B: Physical Sciences)
Proc.Zoo.Soc. London	Proceedings of the Zoological Society of London
Prosymna	C.W. Blegen, Prosymna: The Helladic Settlement preceding the Argive Heraion (Cambridge, 1937)
PT	A.J.B. Wace and M.S. Thompson, Prehistoric Thessaly (Cambridge, 1912)
PTK	A.J. Evans, Prehistoric Tombs at Knossos (Archaeologia 59) (London, 1906)
RTD	A.W. Perrson, The Royal Tombs at Dendra near Midea (Lund, 1931)
Saliagos	J.D. Evans, A.C. Renfrew, Excavations at Saliagos near Antiparos (London, 1968)
SIMA	Studies in Mediterranean Archaeology
SME	N.S. Valmin, The Swedish Messenia Expedition (Lund, 1938)
Sondages au sud-ouest du palais	H. Chevalier, B.Detournay, et al. Sondages au sud-ouest du palais (1968) Études Crétoises XX) (Paris, 1975)
Thera VI	Sp. Marinatos, Excavations at Thera VI (Athens, 1974)
Thimme	J. Thimme, Art and Culture of the Cyclades (Chicago and London, 1977)

Trans.Zoo.Soc London	Transactions of the Zoological Society of London
Tylissos	J. Hazzidakis, Les Villas Minoennes de Tylissos (Études Crétoises III) (Paris, 1934)
VTM	S. Xanthoudides, The Vaulted Tombs of the Mesara (London, 1924)
Wace, CT	A.J.B. Wace, Chamber Tombs at Mycenae (Archaeologia 82) (Oxford, 1932)
Zakro	N. Platon, Zakros: The Discovery of a lost palace of ancient Crete (New York, 1971)
Zygouries	C.W. Blegen, Zygouries, a Prehistoric Settlement in the valley of Cleonae (Cambridge, Mass., 1928)

CHAPTER I

INTRODUCTION

Several thousand objects in bone, ivory, and related materials have been recovered from bronze age contexts in the Aegean. They range from ordinary tools of bone or antler to finely carved works of art in ivory. Until recently only a small fraction of these objects had been studied in detail and even now only the Cretan seals and Mycenaean ivories have received comprehensive treatment. A single study of a technological nature has appeared. Bone tools have been badly neglected.

This study offers a broad approach to the use of these materials throughout the Aegean bronze age. It encompasses aspects of ivory carving as well as bone tool manufacture and rests heavily on the natural properties of the materials themselves. Though in finished form a bone tool and a fine ivory may have little in common, the raw materials are similar in nature. Antler and boar's tusk are also related. There is also a noteworthy group of small objects, including pins, inlays and seals, where these related materials may be used to make similar end-products.

An emphasis on the characteristics of the raw materials is essential for any technological study. These may give insights regarding selection of particular materials for certain kinds of objects and may give clues to methods of manufacture. The availability of these materials in particular areas or periods is also considered, especially the problems surrounding the sources of ivory used during the bronze age. Since the correct identification of materials used for certain small objects is crucial to our understanding of both selection and manufacture methods, a chapter is devoted to that subject. The first half of the study concludes with an evaluation of our various sources of evidence regarding the manufacture of objects in bone, antler and ivory. A brief note concerning the function of these objects is also included.

Another important step in understanding the role of bone and ivory working in the Aegean bronze age is devising a method for describing and discussing the finished objects. This is particularly desirable in the case of bone tools which present special difficulties of nomenclature and have received rather uneven treatment in the past. Systems of classification will therefore be considered and a typology of bone and ivory objects offered, providing a framework for the Catalogue which forms Appendix I of this study.

The final sections of this study are concerned with the bone and ivory industries both at site and regional level. Here an attempt is made to integrate the evidence of individual objects or types of objects with the broader picture of the selected sites and regions. Attention will be devoted to the particular problems which affect our interpretation of the bone and ivory industries at these levels.

This study draws on both published and unpublished sources. Access to published material has often proved difficult or even impossible. Consequently most of the material examined at first hand comes from unpublished collections still in the process of study. The principal drawback here is sometimes insufficient data, since pottery contexts for individual objects have yet to be established, or objects in other materials await their own specialist studies. Nonetheless, without the generosity of excavators whose sites are being prepared for publication, this study would not have been feasible.

The published material presents major difficulties to the student of bone or ivory working in the Aegean bronze age. In the Aegean we are hampered by the wealth of finds, frequently of great intrinsic value. A spectacular find in ivory may easily overshadow a handful of common bone tools. We are also beset by palace sites, demanding years of exploration simply to establish the main architectural aspects alone. Yet these represent only the upper levels of the socio-economic structure of the Aegean bronze age. All this has led to an imbalanced picture of the many underlying domestic activities which occurred for centuries throughout the Aegean, but for which we have comparatively little knowledge.

Fortunately there is increasing interest in technological studies of various classes of artifacts, whether of stone, metal or terracotta. Much more detailed treatment of small finds may be observed in modern excavation reports. Small finds in bone and related materials should also benefit. The evidence for bone and ivory working to be derived from older publications is frequently limited by poor photographs, inadequate descriptions of the objects and lack of secure stratigraphic information. In extreme cases material is known to exist from excavations but was never included in the site reports; in others, material was partially published but the objects have been subsequently lost.[1]

Such factors have largely influenced the form of the present study. The unpublished collections have provided the necessary first-hand experience in working with bone and ivory objects from a technological standpoint, while much attention has been devoted to drawing together the disparate published sources for the Catalogue. The Catalogue and typology are intended not only as a basis for the present study but also as a guide to worked bone and related materials for future reference.

This study is biased toward the smaller objects found in bone and related materials, with special attention devoted to bone tools. Not only have the fine ivories received a greater proportion of past attention, but Poursat's excellent study of Mycenaean ivories, together with the catalogue for those housed in the Athens National Museum has filled a large gap in our general knowledge of Aegean ivory carvings.[2] It is of course largely directed to art historical and iconographic subjects, but the debt of this present study ot Poursat is great, especially for the latter part of the bronze age.

From the technological standpoint we now have Evely's study of Minoan Crafts which deals with certain aspects of ivory carving and is particularly important since Evely also has a first-hand knowledge of tools and objects in other materials.[3] Sakellarakis has also added to our knowledge of Mycenaean ivory carving, which complements certain aspects of that subject as presented here.[4] His discussion of two possible new workshops outside the Citadel at Mycenae, formerly believed to be private houses, forms the most significant contribution of his monograph. For aspects of bone tool manufacture and use we must look to other geographical areas and periods where far more attention has been devoted to such remains than in the Aegean. Reference will be made to some of these studies of experimental manufacture and usage of bone tools as well as the problems of classification and study encountered by colleagues working in other areas.

The present study confines itself to four main geographical regions in the Aegean bronze age, namely the Mainland, Crete, the Cyclades, and the North-east Aegean. In this study, the Mainland refers only to Central and Southern Greece, that is, the Peloponnese, and the regions of Attica, Boeotia and Phocis. A few objects of Mycenaean date from sites in Acarnania and Thessaly are also included. The Ionian islands are not considered at all, while objects from sites in Thessaly and Macedonia are only included in the comparative material on the introductory pages to the Catalogue and then in abbreviated form. The Dodecanese has been excluded as there are but few finds in our materials from that area. In the North-east Aegean, Troy is not given full catalogue treatment chiefly because of the very large collection of finds. Objects are however included in the comparative material and individual items or types from Troy are discussed in the text where appropriate. Material of neolithic date from Saliagos and Knossos as well as pre-Troy I material from the North-east Aegean also provide comparisons.

CHAPTER II

THE MATERIALS AND THEIR PROPERTIES

INTRODUCTION

This chapter will examine the nature and properties of the substances covered by this thesis: bone, antler, boar's tusk and ivory. A special section will present the first evidence for the use of hippopotamus tusk as ivory in Aegean contexts. Discussion will centre on the properties of these materials which make them particularly suited to their use for various types of small objects found on Aegean sites. The question of sources and availability will also be considered. The following chapter will deal with the difficulties of differentiating between these materials in worked form and will present guidelines for correct identification.

BONE

Structure and properties

Bone is that name given to the hard parts of a vertebrate skeleton and is composed of both mineral and organic materials. The proportions of these to the total vary, depending on whether the bone is fresh, has been subjected to prolonged cooking, or to deposition in the soil. In fresh bone the organic portion consists of a fibrous protein known as collagen or ossein, amounting to about 25% of the total, together with cell tissues and certain fats. These last two components disintegrate soon after deposition. Collagen, which provides bone with much of its flexibility and toughness, generally persists for long periods after burial. In certain soil conditions collagen may break down causing the bone to become brittle. It may also be destroyed through prolonged heating, as in roasting or boiling, which renders the bone brittle and consequently unsuitable for use in bone tool manufacture.[1]

The chief inorganic constituent of bone is calcium phosphate, accounting for some 85% of the mineral portion. Calcium carbonate and traces of other mineral salts make up the total. These mineral constituents, which are in the form of minute crystals attached to the collagen fibres, provide bone with its hardness and rigidity. This characteristic is commonly illustrated by the fact that after soaking in dilute mineral acids the inorganic constituents are lost, the bone becomes rubbery and may be tied in a knot.[2] Ordinary soaking in water does not appear to have this effect which should be remembered when considering possible treatments for bone before working.

Bone occurs in two forms: the hard, compact outer bone and the cancellous or spongy tissue found near the articular ends of long bones or running through the flattened bones such as ribs and scapulae.[3] The amount of cancellous material and the thickness of the hard portion is determined largely by the location of a particular bone in the skeleton: that is, the function it must perform. Ribs and other flattened bones which are not subjected to great stress consist only of a thin sandwich of solid bone inside of which is found the cancellous material. The principal features of rib bones and their uses are set out in Figure 1. (See also pl. 1a).

Long bones, those of the limbs, are subjected to considerable stress, notably from weight-bearing. They consist of a shaft of solid bone surrounding the marrow cavity. Cancellous material is restricted to areas near the articular ends where it is covered by a thin wall of solid bone (see fig. 2c and pl. 32). The chief elements of long bones and their names are presented in Figure 2a. The thickness of the shaft is determined by the function of the bone. Thus, the bones nearest the extremities, particularly metapodials[4], but also the lower limb bones (tibiae, radii) have thicker walled shafts than those of the upper limbs, owing to the fact they are subjected to greater weight-bearing. Sheep/goat and cattle metapodials are illustrated on Plates 2a and b respectively, while charts comparing the limb and extremity bones of sheep/goat and pig may be seen in Figures 3 and 4.[5]

Selection

There can be little doubt that selection of bone for working is, in part, determined by the amount of solid bone desired for a particular object. Of the flat bones, only ribs are encountered in great numbers as worked objects on Aegean sites. Metapodials and tibiae are the long bones most commonly found in the worked state. Where only splinters of bone were required it is possible that fragments of the upper limb bones were utilised, although rarely do any occur in recognisable form. Those bones most often found worked on Aegean sites are illustrated in their unworked state in Plates 1 and 2; Figures 1a, 5 and 7a.

The amount of solid bone required is, however, only one of a number of criteria on which the choice of bone for working rests. Indeed, the question of selection of bones for manufacture is not at all clear cut and rests on at least two factors: suitability for a particular object and availability of material. Bone is by far the most readily available of materials under consideration in this study and it is reasonable to assume that the inhabitants of all Aegean bronze age sites had access to it, unlike bronze, for example. On the other hand, supplies of bone for working were not unlimited. An important aspect of husbandry was food supply and bone was merely a useful, and perhaps occasional, by-product.[6] It cannot be assumed that every animal slaughtered would yield a whole skeleton for manufacture, or even any bone at all. As indicated above, bone disintegrates when subjected to prolonged cooking - stewing being the most damaging. From observation I am inclined to think that slow roasting might be less harmful, although I lack substantive scientific proof. Another obstacle in any consideration of the availability of bone is our lack of detailed information about butchery techniques, and whether the inhabitants of the Aegean bronze age were concerned with maximum exploitation of a beast for protein. That is, were certain long bones more valuable for bone tool manufacture or for marrow extraction?

The evidence for selection of bones for manufacturing is, therefore, confusing. In the first part of the following discussion I shall examine the principal types of bones encountered on Aegean sites and how they were used, based on my study of the unpublished collection of nearly one thousand bone tools from Lerna, supplemented by material from other sites where relevant. As will be shown, the evidence suggests a strong correlation between the natural properties of certain bones and their occurrence as worked objects. When, however, we try to integrate the information about suitability of bone types with their availability, we enter the realms of speculation. Nonetheless there is some evidence to support the notion that those bones selected for their suitability on the criteria of shape and strength were also those least likely to be required for nutritional purposes.

Species and types of bone

The domesticated species: sheep/goat [7], cattle and pig provide most of the bone for objects listed in the catalogue of this thesis. The bones of deer (usually Cervus elaphus) account for most non-domesticated examples. Hare, bird and fish are also encountered, although the latter frequently show no definite traces of wear.[8] The ratios of one species to another and of domesticated to wild cannot be determined for the majority of Aegean sites. Older publications rarely indicate the type of bone, much less the species, used for individual objects although occasionally this can be detected from photographs. Where faunal analysts have examined the worked bone while studying the collections of animal bones from a site there is usually more detailed information available. Unfortunately, few sites so studied and yielding a large number of bone objects have been published to date. Only Troy, Lerna and Ayia Irini have produced good quantities of worked bone which has been identified by faunal experts.[9]

The site of Lerna is probably the most fruitful for any discussion of selection of bone for manufacture. Indeed, it is possibly the best Aegean site for a detailed study of worked bone.[10] It has yielded nearly one thousand bone objects from all periods from the neolithic through Lerna VII (Mycenaean), although the main concentrations are Lerna III - V, that is, the Early and Middle Helladic occupation of the site. The vast majority of objects may be classed as tools, while the single largest group is the pins which flourished chiefly during Lerna V. For the most part the objects were identified as to species by Gejvall during the study sessions following excavation in the 1950s. The worked bone is not yet published, although a basic catalogue of objects was presented as part of a doctoral dissertation for the University of Cincinnati in 1967 by E.C. Banks.[11] From this I have taken the identifications by Gejvall as I was not able to consult the original inventory cards held in Cincinnati. I have taken the 'dates' from the inventory books kept in the Argos Museum (Lerna apotheke) which occasionally differ from the phases adopted by Banks. It must be stressed that the phasing for Lerna is provisional, based on the 1950s study sessions and may be altered slightly in the final publication but Professor Caskey assures me that for the purposes of a worked bone study, any changes should have little impact.[12] The following discussion is based on the percentages for species and types of bone found worked at Lerna, broken down by period and presented in Table 1.

At Lerna some 10% of the worked bone objects are made from non-domesticates, chiefly hare and deer. It should be noted that these figures do not include objects made of deer antler which is considered separately below (pp. 26-31). From 21% to 32% of bone objects cannot be identified as to type of bone or species.

This wide range is attributable to the fact that in Lerna V contexts some 165 of the total 275 bone objects are pins whose bone can rarely be determined. For this reason two figures are given, the first reached by excluding the pins; the second taking them into account. Sheep/goat clearly provide the bulk of the identifiable worked bone objects (36%/21%), followed by cattle (20%/16%) and pig (11%/9%).

In Table 2 the figures for Lerna worked bone are presented by type of bone as well as species. In the case of both sheep/goat and cattle roughly 41% of the bones cannot be identified beyond a general division into long bone or rib. The lack of identifying characteristics is due to two factors. First, only segments or splinters of bone were used to make a large quantity of tools, both at Lerna and elsewhere. These fall into Types 5-9 (below pp. 212-17) that is, pointed objects made from splinters of long bones; or Type 18 (p. 229), blunt objects on long bone segments. These pieces may have been cut deliberately for the manufacture of such objects or could be wastes remaining from other processes. The other objects whose bone cannot be identified include Type 10 ('needles'), Type 11 (pins) and Type 50 (toggles). Here the degree of modification to the original bone is so great that distinguishing features rarely remain. Sometimes it is possible to speculate on the source for long pins which were probably made from metapodials of cattle or deer, the only bones which would provide sufficient compact bone both in length and thickness for the manufacture of such objects. In most cases it is impossible to be more precise.

Before leaving the group of unidentifiable long bones it is worth mentioning certain objects not found in the Lerna collection. These include small bone inlays, buttons and seals. Plano-convex inlays such as those from Mallia (56b: 18) and Knossos (appendix IIa, pl. 3a) are sometimes made from bone. The bone selected must have been determined by the thickness and width needed for the finished object. The same may be said for the circular inlays or rosettes occasionally found in bone from Mycenaean sites. Long bones of cattle, notably the thick walled metapodials or tibiae with the large area of flat solid bone toward the proximal epiphysis would have been required for such pieces.[13] On the Knossos inlay traces of the cancellous material are clearly visible on the underside (pl. 3a). Some Cretan seals are also made from portions of long bones, probably cattle, although sheep/goat and pig are also possibilities. In one instance it has been possible to identify the material as metatarsal of cattle (below pp. 17,81 and pl. 4a, b). Such exact identification is, however, the exception and usually one must speculate on the basis of thickness of bone preserved in the finished piece.

<u>Sheep/goat</u>

From the Lerna sheep/goat figures (Table 2) it is clear that where bones can be identified, the most commonly used were metapodials and tibiae. These bones have several important features which make them specially suited to bone tool manufacture. At each end there is an epiphysis which is frequently retained, with slight modification, for use as handle or grip of the object (See pl. 2a and fig. 5; fig. 6 illustrates a selection of Type 1 pointed objects and Type 15 blunts). The epiphysis fits easily into the ball of the hand, unlike the larger epiphyses of cattle long bones (pl. 2b). The distal end is most often encountered; in the case of tibiae it requires some working to soften the sharp projections, but metapodials with the rounded condyles on the distal end are ideal for use as a grip.[14]

The second important feature is the strength and thickness of the bones. As indicated above, the lower limb bones are particularly strong owing to their function in the skeleton. Of these, metapodials are by far the most sturdy. In the ruminants (sheep/goat and cattle), metapodials (sometimes called cannon-bones) are formed by the fusion of the shaft of metacarpals III and IV in the _manus_ and metatarsals III and IV in the _pes_.[15] This can be noted in a furrow on the anterior and posterior surfaces of the bone showing the line of fusion (see figs. 2a, 3, 4, 5c and d; also pl. 4b). In section there is a thin septum of bone dividing the marrow cavity (see figs. 2c, d, e and pl. 4a). This septum is rather more pronounced in the metatarsal than in the metacarpal and may have been considered an added source of strength in bone tool manufacture. Metapodials are also distinguished by a greater thickness to the wall of the shaft than other long bones, making them less liable to shatter whether in the worked or natural state. Furthermore they have a smaller proportion of marrow than other long bones and consequently may have been less sought after as a source of protein.

In addition to strength, the length and straightness of the diaphysis make these bones particularly useful materials for bone tools. Both metapodials and tibiae of sheep/goat can offer 0.15 to 0.20 m of straight diaphysis. This allows the entire circumference of the shaft to be retained for a certain length offering strength and ease in handling, together with sufficient bone to form the working end, either long and pointed or rather short and blunt as shown in Figure 6 a-e. From Lerna there is fairly good evidence to support an hypothesis that there was selection of bone for particular tool type even within the sheep/goat range. Thus, certain blunt tools with a broad flat working end (Type 15b) were made from tibiae whose diaphyses flare out toward the proximal end (see fig. 6h). Tibiae were also used for long pointed objects (Type 1, fig. 6 a, b), although the roundness of the central section of the diaphysis would require considerable working to produce the long fine point.

By far the most interesting case of selection at Lerna occurs between metacarpals and metatarsals. Among Type 1 implements, where distinction between these bones has been possible, metacarpals are four times as common as metatarsals. Although metatarsals, coming from the hind limb, are stronger bones (note the more pronounced septum), they, like the tibiae, have diaphyses roughly round in section. Metacarpals, however, are characterised by a section in the shape of a half-moon, the underside being flat (see fig. 2d). In almost every example at Lerna it is this underside which has been utilised to make the pointed working end. The natural shape of the bone, therefore, permits the manufacture of a sturdy tool with minimal modification to the original shape apart from the removal of the proximal epiphysis and sectioning of the shaft to form the point.[16]

Other long bones of sheep/goat are rarely encountered in appreciable numbers at Lerna or elsewhere. I have not yet found a sheep/goat femur worked on an Aegean site and only a few certain examples of humerus exist (two from Lerna). This is surely due to their unsuitable shape and lack of strength in comparison with the lower limb bones. There is a pronounced curve to the humerus in the lateral view and the femur is somewhat curved longitudinally.[17] Of course it is possible that small sections or splinters of such bones were used to make small objects where the bone cannot now be identified. The radii of sheep/goat are sometimes found in distinguishable form: three examples from Lerna; two from Ayia Irini. Ulnas are used somewhat more frequently, but in no great concentrations. The notched epiphysis may be retained at the grip end or trimmed considerably so that the head is neat and pin-like; the shaft provides a pointed working end (Type 2b, p. 209 and fig. 36). It should be noted that the ulna is attached or fused to the radius in ruminants, especially in older individuals (see fig. 5a). In the case of sheep/goat this leaves a relatively short portion of unfused bone which is not particularly sturdy.

Of the flat bones of sheep/goat there are very few worked examples in the Aegean, although the occasional rib or portion of a scapula is found. The size and strength alone militate against their usefulness in bone tool manufacture.

Cattle

The tables for Lerna show that of those bones identifiable as to type only a small proportion can be distinguished definitely as cattle metapodials. This is not particularly surprising when the size and nature of cattle long bones are considered. Unlike sheep/goat long bones, considerable modification is required to reduce those of cattle to manageable size. Only rarely are objects of Type 1 (e.g. 1a: 11, 25) preserving the whole epiphysis, made from cattle metapodials. The size of the epiphysis alone argues against easy handling (cf. pl. 2a, b). When they can be identified it is often as Type 4 tools (see p. 211-12) where the whole bone is split lengthwise, leaving a portion of the epiphysis as grip and providing a broad-shafted, sturdy pointed implement. At Ayia Irini several examples of a cattle metapodials split lengthwise through the distal condyles (4c:.3-5) are found.

The relatively low occurrence of identifiable cattle long bones among the tool types does not, however, indicate their unpopularity. Rather, the thick-walled shafts, especially of metapodials, gave them greater versatility than other bones considered here. Fine pins (Type 11), inlays (Type 56, 57, 59) and seals requiring both length and thickness of solid bone could be made without impinging on the cancellous structure near the articular ends. Evidence for the mechanics of pin and plaque manufacture from cattle metapodials will be considered in more detail in Chapter IV. Segments of cattle metapodials, possibly rough-outs for pins from Ayia Irini, may be seen on Plate 5a.

A seal from Lebena shows a cattle metapodial utilised in a different fashion (see pl. 4a, b and below p. 81). Rather than the more common longitudinal sectioning of the bone, here the shaft has been sawn through transversely to form one of the ring-shaped seals. It is undoubtedly a cattle metatarsal: identifiable by the circular section of the diaphysis and the pronounced septum within.[18] The depression on the outer wall of the shaft is not man-made but a natural feature of all metapodials of the ruminants. Other seals from Lebena in the same shape, although much more crudely worked and smaller, might also be from cattle metapodials, although this identification is not certain [19] (pl. 4c and Appendix III).

Certain identification of cattle metapodials is, therefore, rare but their importance in the worked bone industry can be inferred from the large number of objects which demand the features of these bones for manufacture. Selection based on the natural characteristics is again surely detectable. Whether this can be extended to the other limb bones of cattle is less certain. Few sure examples of these bones are recorded: from Lerna two each of humerus and tibia; three of radius. They are all worked into large irregular implements and only the lower portion of the tool has any noticeable signs of manufacture marks or wear. It is possible that these were used as 'casual points', that is, rough segments of bone available when a pointed implement was required and quickly modified for use. Cattle ulnas do not occur at all at Lerna and very rarely in bronze age contexts elsewhere in the Aegean.[20]

Only the femur of cattle provides a distinct group of objects, and those are not manufactured from the shaft but from the end of the proximal epiphysis. There are four examples from Lerna (46a: 2-5), but similar pieces are known from Poliochni (46a: 6-8) and Emborio (period VIII) as well as Tiryns (Appendix IIb). The proximal end of the epiphysis has been sliced off, producing a conical object which is then pierced vertically (see pl. 6). They have been termed 'pommels' at Poliochni although it is quite possible that they were used as some sort of weight. While the bone itself is relatively cancellous, these objects are reasonably heavy due to their size. Their weight would have been greater when the bone was fresh.[21]

It is reasonable to wonder whether cattle limb bones other than metapodials could form a significant proportion of the unidentified cattle long bones, either in the shape of implements made on splinters of bone, or as pins and plaques. The former group is certainly a possibility especially with respect to tibiae and radii. These are relatively straight bones and quite thick-walled. Indeed, they might even have been used in pin or plaque manufacture, although there exists as yet no supporting evidence. In the case of tibiae, their triangular section toward the proximal epiphysis may also be considered as a source of bone for the epomion or shoulder-shaped seals from the Mesara (below p. 86). The upper limb bones are much less suitable for bone working since they are comparatively thin-walled, yet stocky. The curvature of their diaphyses, mentioned in connection with sheep/goat bones, is similarly disadvantageous in the production of any objects other than splinter tools.

After the unidentified long bones, it is the ribs of cattle which are most frequently found at Lerna and other sites. These occur in two forms: either whole and little modified except through wear on the distal end (Types 19, 20; pp. 230ff and fig. 1, b (iv)); or split longitudinally to form an extremely thin, flat object, either pointed (Type 12; p. 221, fig. 1b) or blunt (Types 30, 31, pp. 237ff). Those tools utilising the whole rib are scarcely attested apart from Lerna, although this might be due to non-recovery.[22] Split ribs, however, form one of the single most common tool type, especially on sites in the North-east Aegean where they account for a high proportion of bone tools recovered. The popularity of these bones, especially in EBA contexts is difficult to explain. In spite of the natural curvature of ribs, they do offer a length of broad and very flat bone (see pl. 7). The cancellous interior revealed by splitting these bones lengthwise is usually worked or worn smooth (see pl. 7b) leaving an extremely thin piece of solid bone. It would certainly appear that such bones were being selected for their thinness and perhaps flexibility just as sheep/goat metapodials were chosen for their strength and ease in handling. Without concrete information on intended function it is difficult to make more positive assertions. The problems of ascertaining function will be considered further below (Chapter V).

Rib bones from cattle or occasionally deer were also used to make fine blade-like objects with serrated edges (Type 32, p. 238). These pieces, known from both Lerna and Ayia Irini are extremely thin, sometimes only 0.001 m. thick (see fig. 1, b (iii) and pl. 8). Not only has the bone been split lengthwise and the inner cancellous layer been removed, but the upper surface has also been rubbed down considerably. Such serrated 'knives' are made only from rib bones. Here, at least, selection for thinness of solid bone is easier to understand.

Pig

The last of the domesticates to provide bone for manufacture is the pig. Worked pig bones are much less frequently represented than those of sheep/goat or cattle which may, in part, reflect the ratios of pigs to other animals in the Aegean. Occasionally long bones such as tibiae or metapodials are found, but it seems that they were not selected for working as readily as those of the other domesticated species. Even at Ayia Irini, which has a relatively high proportion of pigs, the bones of this animal occur only sporadically in worked form.[23] The shape and nature of the bones were possibly regarded as less suitable. Pig long bones are rather irregular and more curving in shape than those of sheep/goat. Nor are the metapodials as strong: metacarpals and tarsals III and IV are not fused into cannon-bones as in sheep/goat or cattle (see figs. 3 and 4). The tibia is short and rather stocky, not providing the same long straight shaft suitable for bone tool manufacture as sheep/goat.

The fibula of the pig is the one notable exception, particlarly at Lerna. Unlike the fibulae of ruminants which are merely fused vestiges, those of pig are of considerable size (see pl. 1b; figs. 4 and 7).[24] At Lerna, the distal end of the bone serves as a grip, and the natural shaft of the bone is unmodified to the point where it begins to flatten out near the proximal end (Type 3 p. 210f and fig. 7b). Thus, with little working, apart from optional smoothing of the epiphysis and cutting the tip to desired sharpness or bluntness, a neat and relatively strong tool could be made.

Curiously the pig fibula is not universally popular as are the long bones of sheep/goat or ribs of cattle. There is no mention of them in the literature, and were it not for my study of the Lerna collection, I would almost certainly have overlooked their possible use elsewhere. They could not be identified among the worked bone at Ayia Irini. It is possible that a number of the unidentified bones of small animals used to make 'awls and pins' at Troy may be this bone, although I am puzzled by Gejvall's silence on this point.[25] There may be another group from Poliochni (3b: 13-15). At Thermi, I can, however, state that pig fibulae were being used, not only for a large number of Type 3 pointed objects (3b: 16-23 and NC), some needles (10b: 27-29) but also for bone spoons or scoops (17: 3-7, p. 228, fig. 7b). I have also been able to identify pig fibulae used for similar objects from drawings of the worked bone discovered at Emborio (17: 1).[26] Unfortunately with our patchy data both for worked and unworked bone in the Aegean bronze age it is difficult to assess the significance of the appearance of a particular bone, such as the pig fibula, worked on a limited number of sites. Was it a matter of local preference or availability of the material? Was it affected by butchery techniques or cooking?

Non-domesticates

Finally, we may briefly consider bones from the non-domesticated species. As indicated above, deer ribs could be used in similar fashion to those of cattle. Deer metapodials also occur in small numbers at Lerna, although more may exist in unidentifiable shape. They were almost certainly used for some of the longer decorated pins (e.g. 11c: 49) sometimes exceeding 0.15 m. in length where maximum length as well as thickness of solid bone was essential. A deer metacarpal from Lerna marked out for further treatment may represent an early stage in pin manufacture (pl. 5b and p. 121). These bones would also be specially suitable for extremely long pointed tools which also need strength. One such skewer-like tool from Ayia Irini, intact, measures 0.206 m. (4a: 2). By comparison cattle metapodials are rather short and stubby.

Worked hare bones sometimes occur on Aegean sites, including Lerna as do bird (not at Lerna) and fish spines (see note 7 above). A unique occurrence at Lerna is the use of fox metapodials as divider beads.[27] Fish vertebrae are well attested at Lerna and Ayia Irini and although included in small finds, are always in the natural state. Their shape and size do provide a convenient and decorative bead and may well have been used as such (pl.100).[28] On the whole these smaller bones from the non-domesticates do not form a significant proportion of small finds on Aegean sites and it is reasonable to suppose that they were acquired and used more by chance than by definite selection.

Conclusions

The preceding discussion is intended to demonstrate that choice of bone for working during the Aegean bronze age was, almost certainly, not a random process. Certain types of bone were favoured: notably sheep/goat and cattle metapodials and cattle ribs. It is quite likely that the inherent qualities of these bones were specially sought. This at least emerges at Lerna where a large collection is available. It is significant that in many cases the bones used could provide tools with a minimum amount of modification. Many Aegean sites have yielded few bone tools or else few have been preserved for study. Where a site did not support a major bone industry it is possible that use of certain bones was more haphazard.

As mentioned at the beginning of this evaluation of bones used on Aegean sites, the issue of selection is not clear cut. Although one may argue in favour of specific choice, the difficult question of availability of the materials cannot be ignored.

Indeed, it is possible to contend that selection based on suitability was not operative at all and that bone workers had to be satisfied with those bones remaining as waste from the nutritional demands of the community. Bones whose flesh would be removed prior to roasting or which would not be needed for the cooking pot are the most likely candidates for working. Unfortunately, one must rely on educated guess-work. Metapodials, whether sheep/goat or cattle, provide the most certain examples. They have the lowest marrow content of all long bones and have little flesh covering. These could certainly be set aside for bone working with little loss of protein to the family or community. Cattle ribs are more difficult to evaluate as we do not know how the beast was butchered. If the meat were even partially removed from the carcass before cooking, then some, if not all ribs, could be retrieved for use. Significantly they cannot yield protein in the form of marrow. The next most common bones encountered in worked form are those of the lower limbs, particularly the hind limb, such as tibiae of sheep/goat and fibulae of pig. Lower limb bones are not covered by a great amount of flesh. Indeed the size of bones increases in inverse proportion to the amount of flesh they themselves carry as they must also support the weight of bone and flesh higher up the body. The upper limb bones, which are least frequently recorded in worked state, have thinner-walled shafts, bear the most flesh and are thus, most likely to be destroyed in cooking.

These suggestions about availability of bones are, alas, rather speculative. What does emerge is an interesting correlation between those bones offering the least protein (either as flesh or marrow) and those bones most commonly occurring in worked form. Yet without exception it is these very bones which display natural characteristics highly suitable for use in bone working processes. Although the conclusion must remain tentative, it seems that availability and suitability of material may correspond closely in the bone industries of the Aegean bronze age.

HORN

The term horn is commonly used to describe the growths from the skulls of cattle, sheep and goat. It consists of two parts: the inner is a true bony growth, very cancellous in structure, properly termed the horn core. These are occasionally found on Aegean sites bearing saw marks where the core has been removed from the skull and, as a result, included among the small finds. Examples from Ayia Irini are illustrated on Plate 9a. The outer portion is the true horn which is composed of keratin, a nitrogenous substance similar to that found in claws and hoofs. This true horn rarely survives in archaeological contexts.[29] The traces of working on cores does, however, suggest that the fibrous outer material was used. The cores themselves would have little value, being too cancellous for use in the manner of bone or antler.

Sometimes in archaeological publications one finds various artifacts presented under the heading of horn. By this the writers seem to mean deer 'horn' or more correctly antler. As will be shown below antler is a bony substance bearing no relation to the true horn of cattle and sheep. Excavators are therefore urged to abandon the use of the term 'horn' when referring to objects made from deer antler.

ANTLER

Properties

Antler is the term used to describe the bone-like outgrowths from the frontal bones of deer skulls. Unlike bone, antler does not remain with the beast for life, but is shed and replaced annually. It is carried by the males alone. During the period of growth antler resembles bone in having blood vessels supplying nourishment to the developing material. These occur in the inner cavity, which is similar to cancellous bone in appearance, and on the surfaces of the hard outer antler known as the cortex. During growth these outer blood vessels are protected by skin covered in turn by short hairs known as 'velvet'. Once the annual growth has ceased and the blood supply has ended the velvet and skin die and are subsequently rubbed away by the animal. Traces of the blood vessels remain as long furrows running along the length of the antler.

Antler is shed after the rutting season. It becomes detached between the bony process on the skull known as the pedicle and the 'burr' or 'corona' (see fig. 8, pl. 9 b, c). In each subsequent year of growth the antler acquires an extra tine or prong. These are carried on the main beam and are given distinctive names: the brow tine growing low down on the beam; the 'bez' being the second; the 'trez' or 'tray' being the third.[30]

Antler has several important characteristics which distinguish it from bone. Various sources mention that antler, unlike bone, will respond to pre-working treatment. According to Hodges, fresh antler will retain some of its flexibility with prolonged soaking in water.[31] Presumably it does not lose any of its potential strength in the process. Experiments conducted by the Poles have shown that treatment with weak acid solution, notably oxalic acid obtained from sorrel leaves will soften antler to facilitate working [32] (and below p. 118). No proof exists from Aegean sites that similar methods were employed there, but it would be remarkable were such evidence to survive.

The second quality of antler is connected with its structure. Unlike animal long bones which have a hollow marrow cavity, antler is solid even though its centre is cancellous. Antler is thus unlikely to shatter quite so easily as bone under repeated pressure. It is this resilience which has been exploited in the use of antler as soft hammers in flint knapping and in antler picks which are well attested throughout European prehistory. Similar picks are recorded from pre-bronze age contexts in Thessaly and while bronze age examples on the mainland are less certain, several possible candidates do exist including a few from Lerna (see cat. 22: 9, 23: 2; and pl. 11a, b). Hammers or pounders are also known from House Q at Rachmani (period III) and Thermi (26: 4, 5). Rough implements thought to be hoes or mattocks are also recorded including one from an LBA context at Ayia Irini (23: 1, pl. 11c).[33]

<u>Selection</u>

Before continuing our survey of the suitability of antler for certain objects and uses it is wise to consider the availability of the material in the Aegean bronze age. The species of deer most frequently encountered on Aegean sites is the red deer (<u>Cervus elaphus</u>). It is recorded on the mainland and the islands of Kea, Melos and Thera where it was presumably not indigenous but imported at some stage. Fallow deer (Dama dama) have also been reported at Thermi and Troy and are depicted on the Ship Fresco from the West House at Thera, identifiable by their palmate antler.[34] One theory exists suggesting that fallow deer may have been imported to Crete as park deer.[35] I should point out, however, that in my study of worked bone and ivory objects from various Cretan sites I have not come across any examples of worked or partially worked pieces of antler. This is in marked contrast to the island site of Ayia Irini where nearly one-quarter of the preserved examples of worked 'bone' are in fact antler, although much of it is in the form of wastes or roughouts and not finished products.

Based on my experience with unpublished groups of worked bone, antler and ivory I suggest that antler was employed in the bone industry if and when it became available. I have not yet found any evidence to suggest that antler was being traded as a raw material to sites without local supplies. This is supported by the work of Clive Gamble in the Cyclades who indicates that at least one specimen from Akrotiri is attached to the skull.[36] There is a similar example of a pedicle with portion of main beam still attached from Ayia Irini (see pl. 9b, right). A piece from Lerna shows portions of the pedicle, burr and main beam (pl. 9c, left).

Where red deer were present the availability of antler was probably at least as great as animal bone. This is due to the fact that even without hunting, the deers' shed antler could be collected yearly. Several pieces from Ayia Irini indicate that shed antlers were, in fact, collected and subsequently worked (see pl. 10 a, b). There is also a possible example of shed antler from Lerna. In this connection it should be noted that Hodges states that shed antlers are much harder than those taken from a freshly killed beast.[37]

Uses

The number and range of objects made from antler on Aegean sites is somewhat difficult to assess. The material of large objects such as picks, hammers and the like is easy enough to identify. While the use of antler is not well-attested in publications for making other implements or small finds this may simply be a case of non-recognition. When heavily worked, antler may resemble bone to the non-specialist. It may also pass undetected if working from photographs alone. In fact, at the outset of this research I did not consider the use of antler sufficiently important in the Aegean to be included in this study. The collections from both Lerna and Ayia Irini have altered the picture. Perhaps even more noteworthy is the occurrence of antler pointed objects at the Citadel House, Mycenae in secure LHIIIb deposits (see below p.287).

Most antler implements, whether pointed or blunt, are made from a wedge cut from the main beam of the antler. Plate 10a (right) shows a waste piece of main beam from which such a segment has been cut. This would provide the object with an upper surface formed from the cortex of the antler and a under-side of cancellous material. The furrows created by the blood vessels are often visible on the upper surfaces of implements although they are usually rubbed down toward the working end (see pl. 12a) and worn down through use at the grip end. The celt-shaped tools (24: 1-5) from Ayia Irini, cut from a large section of main beam illustrate this feature clearly (pl. 12b). Few antler tools are cut to a very sharp point: even the pointed examples tend toward a smooth and rounded tip. It is extremely likely that the material does not lend itself to sharpening as does bone because of the amount of cancellous material present. Antler seems to have been reserved for such purposes where resilience was particularly required. Unfortunately, I can offer no substantive proof for this suggestion since at the time of writing I still lack antler in my collection for experimental purposes.[38]

Antler tines with some traces of working and more definite signs of use are present in both the Lerna and Ayia Irini collections (Type 22). The tip, left in its rather blunt natural state, is often highly polished, probably from a rubbing motion. Tines, with their cancellous and not hollow interiors also provided a source of handles for bronze awls (Type 37b). One unique and highly decorated example with incised chevron designs has been found at the Citadel House, Mycenae (37b: 6, pl. 13a, fig. 9).

Possibly the most surprising feature of antler working which I have encountered is this use of the material for decorative objects and not merely tools. To be sure, the range is rather limited by the amount of solid antler, but no more so than bone. Apart from the Mycenae handle, there is a fine knob or pommel from Ayia Irini (42a: 2, pl. 13b) where the cancellous nature of the material is clearly visible. It was probably cut from the main beam. Also from the same portion of antler discovered at Ayia Irini are: a decorative attachment (68:1 , fig. 9b); a figure of eight inlay (61: 4, fig. 9c); and a small spoon (27: 1, fig. 9d). Perhaps the most remarkable of all is part of a circular pyxis cut from a substantial section of main beam (65:6 , pl. 13c).

Conclusions

These few objects suggest that antler had a greater versatility than hitherto recognised in the Aegean. Apart from the rough and heavy tools it could provide strong and resilient small implements and even decorative objects of limited size. For the latter its only possible drawback is that it does not acquire the high polish of bone or more particularly, ivory. Perhaps this factor, together with the cancellous structure, prevented antler from being widely used in pin manufacture. One or two possible examples do exist and perhaps more have passed unnoticed. Although evidence for antler working in the Aegean is still restricted, there is reason to believe that it could provide a valuable and easily obtainable supplement to supplies of animal bone. On Ayia Irini it might even have served as a cheap local substitute for ivory.

BOAR'S TUSK

Boar's tusk is one of the best known materials on Aegean sites, doubtless because of its use for the famous boar's tusk helmets. Yet little has been written about the material or about the animal in the Aegean or for that matter in European contexts. The tusks, lower canines of <u>Sus scrofa</u>, are composed, like other teeth, of dentine covered by a layer of enamel.[39] They are trihedral and are hollow at the proximal end to allow formation of dentine in the root cavity and attachment to the animal's skull. Toward the tip the dentine becomes solid. At the distal end is an oblique wear facet caused by rubbing on the upper canine (see pl. 14a, and fig. 10a). Like the dentine of elephant, or more particularly, hippopotamus tusk, that of boar is set down in fine layers which can sometimes be discerned in worked pieces. Usually a microscope is required. I have no information as to its hardness, but presumably it is comparable to true elephant ivory or bone, that is, about 2 on the Mohs scale. The enamel covering is visible as fine ridges on the surface, rather translucent and apt to glisten in the light (see pl. 15a).

The availability of boar's tusk in the Aegean bronze age cannot be ascertained completely. Certainly the animal was present on the Greek mainland and Crete, and it is also attested on Kea. From Thermi I have discovered no examples of tusk among the large unpublished collection of worked bone from the site and at Poliochni there is but a single example.[40] While this may reflect no local interest in the material it is possible that the beast was not indigenous to these islands and that the Poliochni example is an import.

Whether the animal was hunted especially for its tusks is an open question. In the EBA the relatively low number of worked tusks suggests that it was used, as antler, when it became available. Normal hunting of boar for meat, or the killing of a dangerous local specimen would probably account for most tusks occurring in EBA contexts. That the boar was a fearsome and perhaps lethal enemy must not be forgotten and the prized tusks were its most powerful weapon. A chalcedony lentoid from Vapheio (Athens 1772) illustrates a defenceless man at the mercy of a charging boar.[41] Still, the possibility of the animal being hunted for sport, as in more recent times, is suggested by the representation on the Lasithi dagger, dated by Evans to MMII.[42]

Larger quantities of tusks are reported by the MBA as at House E at Eutresis.[43] By the LBA, when helmets covered with plaques of boar's tusk came into vogue, the boar must have been hunted on quite a wide scale. I have heard it suggested that the tusks of some forty boars would have been required, although I feel this figure is a little high. At least three plaques could be extracted without difficulty from each tusk at the root end, that is, one from each facet. With a little more effort in carving, several smaller pieces could be obtained from the distal end. Even were the figure of forty halved, the possession of a helmet would, however, have demanded much hunting. The concentration of tusks, often unworked, in Mycenaean settlements and burials, suggests that they might have been a symbol of prowess not unlike the trophies of antler and big game horns today. It is worth pondering also whether, by Mycenaean times, any localised control of boar hunting or trading of tusks occurred.

Helmet plaques are, of course, the principal use of boar's tusk during the Aegean bronze age but other small attachments of different shape from the conventional ones are also known (see pl. 15a for examples from Ayia Irini). Less immediately recognisable is solid boar's tusk as it closely resembles elephant ivory. A length of roughly 0.15 m. may be taken as a norm for tusks in the Aegean. Approximately one-third of this will be hollow root cavity and perhaps another third would be wasted through curvature of the tusk and the wear facet. Nevertheless, this still leaves a rough cone about 5 cms. in height for working. Several partly worked pieces of tusk confirm that this portion was not wasted: see pl. 15b from Ayia Irini and fig. 123 from recent excavations at Khania.[44] A unique piece of unknown provenance from Tiryns is also cut from a solid portion of boar's tusk (Appendix IIb, pl. 117). The use of this material, if the identification is indeed correct, for inlay strips in Circle A at Mycenae (59: 20) is most unusual. In general the pronounced curvature of the tusks would impede the manufacture of straight, flat objects. There is no evidence that boar's tusk was ever used for pins.

The Cretan seals offer best scope for considering additional uses of boar's tusk. Certainly it had the advantage of being locally available, albeit in limited quantities, and is a more attractive material than bone. The question of re-identification of certain seals as made from boar's tusk will be considered more fully in the next chapter. Here it may simply be stated that a number of seals, hitherto designated 'ivory' are clearly manufactured from boar's tusk. One of the most obvious examples is HM 434 (<u>CMS</u> II.1, no. 11) from Ayia Triada. One seal face is larger than the other which would be expected were a little modified section of tusk being used. The 'missing centre piece' from the lower and larger seal face is the last vestige of the root canal of a boar's tusk (see fig. 10b). In fact, even where the tusk becomes completely solid there is usually a fine dark line running length-wise down the middle of the tusk toward the tip; a remnant of dentine formation. Regrettably I cannot offer a photograph to illustrate this point, but have observed it on several occasions.

Boar's tusk seems, therefore, to have played a small yet important role in the bone and ivory industries of the Aegean bronze age. Its use for objects other than helmet plaques is particularly important for the question of local materials substituted for imported elephant ivory. Finally, suspicions concerning the use of boar's tusk, at least from time to time, for Cretan seals, now appear to be justified.[45]

SHELL

The use of shell in the Aegean bronze age could easily form the basis for a separate thesis, requiring considerable knowledge of the species concerned and their distribution. For the most part, objects made from shell are, therefore, excluded from this thesis even though they are frequently found in the small find lots for bone and related materials. A few objects of shell have been included in the Catalogue of this thesis. Although the basis for inclusion is somewhat arbitrary, certain criteria have been employed. If the shell, especially spondylus, has been used for the carving of small objects in the round, as in the case of the unique and delightful duck from Ayia Irini (pl. 16.64b: 1) it is included. Similarly recorded are small pieces of shell, notably mother of pearl, which were used rather like bone or ivory to make small plaques or inlays (e.g. 59: 11-13 from Mallia). Finally, pierced shells are often encountered together with pierced teeth or fish vertebrae suggesting their use as beads: some, but not all examples of these are mentioned under Type 52 in the Catalogue. Shell and its uses in the Aegean bronze age are thus allied to the wider question of the bone industries of this time. Only time and space have deterred me from pursuing it in full.

IVORY : INTRODUCTION

Ivory is the name given to the tusks of elephants and is composed of pure dentine. It is also used, somewhat loosely to describe related materials: tusks of wild boar, hippopotamus and narwhal. The latter, owing to the geographical distribution of the species, does not concern us in this study. Nor does a substance called vegetable ivory which is used in Japan for the carving of netsuke.[46] During the course of my research I have come upon convincing evidence that hippopotamus tooth was also a possible source of ivory in the Aegean.

Two main sections on ivory are presented below, the first concerning elephant ivory: its nature, uses and availability during the Aegean bronze age. When unqualified, the term ivory[47] will refer to the tusk of elephants. It must be recognised, however, that with the discovery of hippopotamus tusk, unworked and partially worked on two Aegean sites, some objects hitherto published under the simple heading 'ivory' may be made from hippopotamus ivory. Since differentiation between these two types of ivory is exceedingly difficult I have made no attempt to identify the type of ivory used unless I have handled the objects themselves. Most published ivory objects are, therefore, discussed under the heading of elephant ivory, although the possibility that some may have been carved from hippopotamus tusk is now open. The qualities, sources and possible uses of hippopotamus ivory in the Aegean bronze age will be presented in the second section on ivory.

ELEPHANT IVORY

Structure and properties

The valued material of ivory is obtained principally from the tusks of elephants which are, in fact, the animals' upper incisors. Unless deformed or damaged, adult males will carry two tusks, one slightly larger than the other indicating preferred usage, similar to 'handedness' in humans. Females of the African species also carry tusks, although smaller than those of males. Tusks may sometimes be lost through injury but hunting the animal expressly for them is the chief source of ivory today. There are strong indications that ivory was obtained in this fashion in prehistory.

Tusks are composed wholly of dentine except near the root cavity where it is covered by a layer of enamel. Dentine, like bone, is composed of both organic and inorganic elements. The chief organic component is also collagen, although it comprises only about 18% of the total as compared with 25-30% in bone.[48] With age and deposition the collagen in dentine also deteriorates: a factor which can allow scientists to determine the authenticity of possible forgeries of ancient ivories.[49] Of the inorganic constituents, calcium phosphate is the chief component of dentine (about 82%). Unlike bone, magnesium phosphate is the second most important compound while calcium carbonate only occurs in small quantities.[50]

As with bone, the formation of dentine is a complex mechanism and takes place in two stages. The first is the production of an amorphous dentine matrix by the odontoblasts, specialised elongated cells, radiating from the pulp cavity. No formative cells are trapped in this matrix as happens in bone, causing dentine to be non-cellular. The second stage is calcification which occurs more slowly than in bone. It takes place only when the new matrix comes into contact with previously formed dentine. This means that the dentine is built up in layers, gradually encroaching on the pulp cavity.[51]

The other unique aspect of dentine formation is the fact that it is built up in tubules, extensions from the elongated odontoblasts.[52] These dentinal tubules may be seen clearly in a partially decayed block of ivory from the Citadel House, Mycenae (see pl. 17, 74: 24).[53] The tubules run through the tusk from the pulp cavity in two intersecting curves. In transverse section the intersection of these curves forms a diamond-shaped pattern, often described in the literature as 'engine-turning effect'.[54] Plate 18a shows this feature on a portion of tusk in my own collection. In practice, this engine-turning can rarely be detected in any of the pieces of ivory from the Aegean, partly due to obliteration by manufacture marks and deterioration of the material.

Much more frequently noticeable are the lamination lines or concentric growth rings caused by the deposition of dentine in layers, gradually encroaching on the pulp cavity of the tusk. The presence of these long parallel lamination lines, usually a slightly darker colour than the rest of the ivory is one of the chief means of identifying the material. They do not, however, significantly affect the ability to carve the material when fresh, although carving along the grain can enhance the appearance of a finished piece. Fresh ivory should not fracture along these lines unless dropped onto a hard surface, although pieces from archaeological contexts often are split regularly along these laminations. A large wedge of ivory from the Citadel House, Mycenae illustrated in Plate 18c has deteriorated in this fashion. This may occur after excavation if the piece is subjected to extremes of temperature and moisture. As ivory is hygroscopic it is important to try to maintain it in stable conditions.[55] While the presence of lamination lines provides the most helpful clue in identifying ivory, they are not always readily visible in worked pieces. This matter will be discussed in greater detail in the next chapter (pp. 93-96).

The compact structure of ivory based on its non-cellular formation, and the amounts of solid material available in a tusk make it an ideal substance for carving. Unlike bone, which offers relatively small volumes of solid material to the carver, the average tusk will offer little restriction to the size and shape of finished object. It is difficult to assess the average size of tusk, even from modern sources, although Ritchie mentions a weight of seventeen pounds as approaching the norm.[56] The only restrictions on the carver are the root cavity and the upper end of the tusk and outer enamel. The root cavity, for formation of ivory and attachment to the skull, does however, have solid ivory around it as is clearly visible in Plate 23a and b showing one of the Zakro tusks. This end of the tusk would have been ideal for use in the manufacture of cylindrical pyxides such as those known from LBA sites (Type 65).

The other difficulty with this proximal end of the tusk is the enamel coating. It is detectable to the touch as fine parallel ridges and is usually less than one millimetre in thickness.[57] A photograph of a piece of ivory in my collection illustrates this feature (see pl. 18b). On the Mohs scale of hardness this enamel registers about 4, that is, somewhat harder than the actual ivory beneath it which is 2-3 on the Mohs scale.[58] Ritchie suggests that the enamel serves to protect those parts of the tusk where the ivory is weakest, namely at the root cavity, which seems to be confirmed by the fact that the enamel never continues for the full length of the tusk. Beyond the enamel layer, toward the tip of the tusk, are long irregular black lines on the outer surface which penetrate a few millimetres into the ivory beneath, rendering this outer portion similarly useless for fine carvings. The appearance of these lines shows up in two unworked tips of tusks in my possession (see pl. 19). Such surface features are, of course, rarely encountered in ivories from the Aegean, although several pieces from the waste material of the Royal Road ivory deposit at Knossos may serve as examples.[59] Plate 20a and b show several waste fragments of ivory with portions of the enamel remaining. Two pieces in Plate 20b (top row) have remains of drill holes, which suggests that they were either scraps used as practice pieces or else the craftsman intended to remove the remaining traces of enamel by means of abrasion. Plate 20c shows another piece from the Royal Road deposit with rough tool marks on the outer portion of the tusk near the tip. Several faint, irregular black cracks are just visible in the photograph. This feature may likewise be seen on a partially worked tusk tip from the Citadel House, Mycenae (see fig. 11a, pl. 41a).

Apart from the slight problems connected with the root cavity and extreme outer portion of the tusk, the carver is presented with a relatively easily worked substance, no harder than bone, but with far greater versatility as to size and shape of object possible. To judge from several segments from the Citadel House, tusks of considerable size were available. One partially finished piece (see fig. 11c, pl. 42a) gives an estimated diameter of solid tusk at nearly 0.16 m; another wedge (see fig. 11 b) probably approached 0.20 m. in diameter. The length of tusk permitted the carving of large rectangular relief plaques as those known from Mycenaean sites. Rather less common are carvings in the round such as the acrobats from Knossos, the well-known trio from Mycenae and the recently discovered head and lion from the Citadel House (64a:14,64b: 2 pl. 54a, b). On the other hand, ivory was equally suitable for a wide variety of small objects such as seals, pins and inlay plaques. A large number could have come from a single tusk (below p. 45) or carved from fragments left over from other processes. A striking example of the use of wasters for secondary manufacture is found in the Knossos ivory deposit where such off-cuts were used to make minute ivory pegs ca. 1 cm. in length and 2 mm. in diameter (below p. 139 and pl. 21a). Plate 21b and c show how these pegs were used in small ivory inlays. (Compare bronze nail in bone plaque from Ayia Irini on pl. 3b).

Selection

Set against these many advantages of ivory are the questions of strength, availability and 'cost'. One large class of objects, pointed and blunt implements, is never found in ivory during the

Aegean bronze age.[60] Here we have another example of the interplay between the two factors of suitability and availability seen above in the use of bone types. Ivory, as an imported substance was, presumably, quite costly at all stages of the Aegean bronze age and never widely available outside the palace complexes and main settlements. Furthermore, it is doubtful whether ivory could have withstood continued pressure in use, either for piercing or polishing. While Ritchie is quite right in asserting that fresh ivory should not fracture, I personally am doubtful about its resilience under pressure. The lower level of collagen in comparison with bone, and lack of fatty substances would certainly reduce its flexibility, while the lamination lines do offer natural paths for fracturing. Ivory was, of course, used for functional items as well as decorative pieces during the Aegean bronze age, but in no instance, whether as dress/hair pins, seals or fine combs, do they undergo the constant battering to which an ordinary bone tool is subject. Moreover even on palace site during the LBA the continued use of bone for many pins suggests that ivory may not have been well-suited to this purpose.[61]

The question of availability of ivory in the Aegean is open to considerable speculation, based on the extant remains of this material and our scanty evidence of trade-routes. We cannot even be sure of the ultimate source of the raw material: Africa and the Near East both possessing the necessary elephants. The chief point is that ivory, unlike the other materials considered here, was not a locally available substance and by-product of hunting or husbandry. Not only had it to be imported but it cannot even be classed as an 'essential' import as copper or tin might be termed. It was then, as now, a luxury commodity.[62] The distribution of ivory throughout the Aegean will readily support this suggestion.

Early Bronze Age: Distribution and quantities

Table 3 sets out in simplified form the main groups of ivory, unworked and worked, for the principal regions of the Aegean. It is quickly noticeable that the only significant deposits of ivories in the EBA come from the Mesara tholoi and other burials in Crete datable to EMII-MMIa. At present there are but two pieces from EBA contexts on the mainland; one small knob from recent excavations at Thebes (45: 26) and an ivory leg from Lerna IV. It should be pointed out immediately that the Lerna context was considerably disturbed and open to question.[63] Even if we accept the context, the leg (64a: 5 , pl. 22a) betrays signs of foreign, perhaps even Cretan workmanship. This is particularly interesting as ceramic evidence also points to links between Lerna and Crete toward the end of Lerna IV (EHIII). Furthermore there is little evidence from any period at Lerna to indicate a local tradition of carving bone or related materials into objects other than tools or the highly decorated pins which flourish in Lerna V. The leg is thus almost certainly an import. Elsewhere in the Aegean ivory is likewise scarce. There are just three objects of ivory from the whole of EBA Troy (Cincinnati excavations only) including one piece which is more likely to be bone. (above n.60). There is also the imported cylinder seal from Poliochni.[64] The Cyclades have not yet produced any worked ivory of EBA date.

The appearance of ivory in Early Minoan contexts could not be unduly surprising when set against Crete's move away from a purely subsistence economy from the EMII period onwards. Its absence in other areas of the EBA koine such as the Cyclades and the prosperous mainland settlements at Lerna or Thebes is more puzzling. Perhaps the stronger sea-going traditions or proximity of Crete to the trade centres of Egypt and the Near East were able to provide the island with this item. Of course, the lack of stratification in most early Cretan burials hampers any assessment of the quantities of ivory actually available in the Early Minoan period. Objects of ivory which may be securely dated to EMII are extremely rare. Of the so-called 'ivory' seals from the EMII strata of Tomb II A at Lebena, only two could, in fact, be made from this material.[65] So, for the purposes of this discussion the conventional dating EMII-MMIa will be retained, recognising that a significant proportion of ivory seals may belong to the latter part of the period.[66]

To these caveats another must be added: the absolute quantity of ivory extant from these EMII-MMIa contexts is not over large. By far the majority of items are the Cretan seals, followed by amulets or figurines, and pommels. Using the available publications only, another researcher and I have both reached a figure of approximately 350 supposed ivory seals of this date.[67] To this figure may be added perhaps twenty more pieces: amulets, pommels and figurines (including those from the Giamalakis collection of unknown provenance and which might be of bone). Even at 370 or 400 pieces we have no large quantity of ivory. Nevertheless, there is a further adjustment needed in these calculations:

deleting those seals published under the heading of ivory but actually made from bone or boar's tusk. The arguments for re-identification of the Lebena seals published as 'Bein' in CMS and recorded as 'elephantodos' in the Iraklion Museum Inventory [68] will be presented more fully in Chapter III and Appendix III. Here it may be stated that of 33 seals examined under the microscope the following results were obtained. Fourteen seals may definitely be classed as bone with a further two as 'probably bone'. Eleven are clearly ivory while the remaining six should be termed 'bone/ivory' in the absence of conclusive features. Lebena should not be regarded as typical of all Mesara tholoi and I would not wish to suggest that the majority of ivory seals are under suspicion. Even a non-expert may see that most of the large ivory cylinders from tholoi such as Platanos are indeed of ivory. Nonetheless, perhaps as many as 10% of the so-called ivories of the EMII-MMIa period deserve re-classification. Specific examples from the Iraklion Museum study collection will be discussed below (p.86 ff).

I should now like to demonstrate how we may reach a very rough idea of the amount of ivory, in terms of numbers of tusks, represented by the EMII-MMIa objects mentioned above. Allowing for a proportion of incorrectly identified ivory seals in the publications we may take 350 as an estimate of extant objects. As indicated above, it is extremely difficult to ascertain an 'average' for tusk size, especially for the Aegean bronze age. So for the purpose of this argument we shall take the smallest tusk currently known from an Aegean context: unpublished tusk no. 4 from Zakro [69] (pl. 24a, lower tusk). This measures only

0.610 m. in length; 0.085 m. across the root end and 0.066 m. at the tip. It is apparently complete, although badly burnt. If one subtracts some 20 cms. for the root cavity and allows a generous 4 cms. in length for every seal, calculating only one seal to be cut from each transverse section, it produces a figure of ten seals from Zakro no. 4 (see fig. 12a). A more sophisticated method of determining the amount of ivory available for use in this tusk is illustrated in Figure 12b. Here an attempt has been made to calculate the volume of the tusk using the known measurements and mathematical formulae.[70] The result is approximately 1600 cubic centimetres of ivory available for carving. Taking a notional figure of 125 cu.cms. (5 cm^3) as being required for the manufacture of an ivory seal, we arrive at a figure of twelve seals from Zakro no. 4. In fact, it is likely that as many as fifteen or even twenty could be made provided that tusk was handled properly. The majority of Cretan seals were no more than 0.025 to 0.03 m. in height and 0.015 to 0.02 m. in diameter. Zakro no. 4 is also an exceptionally small tusk. Even so, using the lowest figure of ten objects per tusk we reach the number of 35 tusks at most for the Cretan objects extant from the EMII-MMIa period. Were tusks the size of Zakro no. 1 (pl. 23a) used, or those estimated from the Citadel House (above p. 41, fig. 11b, c), perhaps as few as ten tusks would suffice to produce the extant ivories of this period. When taken over a period of several hundred years we should be struck by the comparatively small quantity of ivory actually involved.[71]

Before leaving the question of availability of ivory in the EBA and early MBA of Crete it might be worth considering several questions yet to be solved. To date we have no indication as to the form in which the material was transported to Crete in this period: whether as whole tusks or in pre-cut blocks. As yet we have no examples of unworked pieces of elephant ivory on Crete before the Late Minoan period (but see below pp. 70 ff on hippopotamus ivory). The few examples from Platanos are surely blanks for seal manufacture, already in an advanced state of working.[72] It may be supposed that during the initial stage of transport of ivory to Crete, it remained as tusks to avoid breakage or deterioration through exposure to dampness and heat. Its course after arrival, indeed whether it arrived at a central entrepot or at several cannot be certainly ascertained. However, in an attempt to suggest possible mechanisms of distribution, two models are presented in Figure 14. An accompanying map (fig. 13) indicates the location of the chief find spots of EMII-MMIa ivory objects. This shows that the Mesara has yielded by the majority of ivories, while Central Crete, including Knossos, Archanes and Mallia and Eastern Crete have much smaller amounts. In the Mesara, the tholoi at Platanos and Ayia Triada produced over 100 items; that is, approximately one-third of the total objects.

Model A suggests possible distribution of ivory throughout the island supposing a centralised entrepot which might have been a south coast port rather than the port of Knossos judging by the preponderance of ivory in the Mesara. From there the ivory may well have remained in tusk form through the second stage to regional markets or trade centres. The acquisition of ivory by prosperous settlements, for instance Ayia Triada, may similarly have been by tusk. Smaller settlements might have been able to acquire their ivory at regional markets or by barter in small blocks suitable for carving a handful of objects. An alternative suggestion is that the ivory seals found in less prosperous or remote settlements were not in fact manufactured there, but received through trade or as dowry from their more affluent neighbours. In this connection it may be interesting to consider the Lebena group with about half the seals being bone. It is clear that the inhabitants were relying in large measure on locally available resources for seal manufacture and acquired only small quantities of ivory either to work on the site or as ready-made seals. An examination of the shapes of seals in the Kali Limenes group from the Metaxas Collection [73] suggests that as many as one-third were of bone or boar's tusk. This site too is located to the south of the Asterousia Mountains, on the coast, and some distance from the main ivory-yielding tholoi if the Mesara.

A second model (see fig. 14b) does not differ greatly from the first either at the beginning or end of the hypothetical ivory route but suggests that tusks may have reached several ports in Crete, rather than a single centralised distribution point. This is inferred partially from the Zakro tusks, albeit of the Late Minoan period, together with the marked benefits of sea transport. Unfortunately, there is little direct evidence to support either model. They are presented largely to promote further discussion of trade and dispersal of imported meterials throughout the island before the rise of the great palace centres.

Middle Bronze Age: Distribution

Table 3 shows that a similar dearth of ivory continues into the MBA in most Aegean regions apart from Crete. The Theban plaque (57a: 20) is of some interest as the workmanship and style suggest local manufacture.[74] The fragmentary lid from Lerna (pl. 22b) may, however, be a worked foreign import. Even by the time of the first grave circle there are only a few ivory objects on the mainland. From the Cyclades there is a minute and fragmentary button in ivory from Ayia Irini (51a: 1) which seems to be true ivory and not boar's tusk. There is also a recent find of 'fragments of unworked ivory' from the new Phylakopi excavations.[75] Where there are but few isolated finds I would venture to suggest that blocks or pieces of ivory, rather than whole tusks, were received in trade, not from their original source but via Crete. In the MBA ivory was still a rarity.

Even on Crete there is some difficulty with the evidence for the earlier part of the MBA, though Kenna is surely wrong in discerning a decline in ivory usage at the beginning of MMI.[76] There are five ivory seals from the MMIb-MMII workshop complex at Mallia.[77] In addition there are several small finds, reported as ivory, from the First Palace at Phaistos: a finely worked handle (45: 23) and two fragments with grooved decoration (59: 23). The numerous small inlay plaques from the Chrysolakkos cemetery, Mallia, are however, said to be bone.[78] Nonetheless, considering the nature of much of our early palace period evidence, together with the increasing use of harder materials for seal manufacture, I do not feel that we need seek elaborate explanations for the small recovery of ivory from these contexts.

Late Bronze Age: Distribution and Palace Workshops

By the beginning of the LBA quantities of ivory do increase dramatically, especially at Knossos, with the use of ivory for a wide variety of objects from inlays, hair/dress pins, to three-dimensional carvings. That ivory working had approached the level of a palace industry is attested by the ivory deposit from the Royal Road at Knossos (see further Chapters IV and VIII). The discovery of an unworked piece at Palaikastro [79] suggests that ivory working was not confined to palace sites only. The remarkable discovery of whole tusks at Zakro indicates that in this period, at least, the raw material was reaching Crete in this form. The excavator, Professor Platon, has suggested that these tusks might have been en route to other points on the island [80] though use in the Zakro palace workshops is equally plausible.

In the Cyclades there is a slight increase in ivory finds with the LBA, but no great concentrations have yet been found. Few are mentioned in the preliminary reports from Akrotiri and only a handful of pieces exists from Phylakopi and Ayia Irini. The few examples from the latter site are, however, quite tantalising: a finely worked, though undecorated comb (34a: 6, pl. 25a), a portion of an ivory pyxis with incised decoration (65: 5, pl. 25b) and a beautifully worked button (49b: 1, pl. 25c) with incised decoration similar in style to the gold buttoms found in Grave Circle A. There is also a roughly worked piece of ivory, perhaps intended for use as a plaque (74: 1, pl. 49a) indicating the possibility that ivory was worked on the site. These finds come from the LMIb destruction levels at Ayia Irini. On the whole valuable small finds are rather rare, even from House A. This has led to the suggestion by Dr. E.V. Schofield who is publishing that house, that inhabitants had sufficient time before the final catastrophe to remove themselves and small portable objects of value.[81] The remains in bone, ivory and related materials from the site have helped to support this conjecture, which might also be applied to Akrotiri.[82]

On the mainland finds in ivory occur in increasing quantities from the second grave circle and earlier tholoi and chamber tombs (LHI-IIa) through to the height of the Mycenaean ivory industry in the LHIIIa and LHIIIb periods. By the time of their destruction, the major Mycenaean centres almost certainly had their own workshops as illustrated by the finds from Thebes and Mycenae.[83] The large quantity of ivory discovered at Pylos, together with the mention of this material on the tablets also suggests the presence of a palace workshop.

Mycenae itself may have supported more than one workshop. Apart from the so-called 'artisans' workshop' on the eastern side of the palace, it has been suggested that the recent discoveries in the Citadel House indicate the presence of a second. The excavator, Lord William Taylour, believes that ivory working occurred somewhere on the site and Sakellarakis includes the Citadel House as one of his examples of Mycenaean workshops.[84] To be fair it should be noted that the latter's comments were based on the preliminary reports issued before a study of the ivory remains was undertaken. It must be stressed, however, that the two major supports for the workshop theory are open to question. The existence of an unworked elephant tusk mentioned in preliminary reports [85] is incorrect (see below p. 60 on hippopotamus ivory), while the unworked and partially worked blocks were chiefly found in a small storeroom or shrine near the Temple. A workshop may well have existed in the vicinity of the Citadel House, but its precise location is not wholly certain. Further discussion of workshops is presented in Chapter IV while a more detailed consideration of the Citadel House evidence may be found in Chapter VIII.

The wide use of ivory for fairly large items, either in the round or as plaques and pyxides reveals that trade in ivory had reached considerable proportions. We have as yet no clue to the distribution mechanisms for ivory any more than for a host of other materials in the Mycenaean period. Thus it is impossible to say whether there was any centre specialising in the acquisition and dispersal of the raw material or whether it was shipped direct to a number of regional centres. Similarly, it is difficult to assess how readily available ivory was to less prosperous centres. Nevertheless small quantities of ivory objects have been found in tombs near the outer limits of the main Mycenaean sphere: for example Dimini (Type 60, ANM 3387) and Mega Monasterion in Thessaly (56h: 12), and Ay. Ilias tholos tomb in Aitoloakarnania (43: 3).

After the destructions at the end of the LHIIIb period, finds in ivory are far less frequent. Some pieces of possible LHIIIc date are known from the Citadel House (p. 293) and a few have been reported from the new excavations of the Unterburg at Tiryns (e.g. 34a: 37). The cemetery at Perati has also yielded a number of items, plain combs, pins and discs but all are very simple in comparison to the fine carvings of the preceding period. It is likely that ivory supplies were drastically reduced and by the end of the bronze age had almost ceased. As an imported material this would be in keeping with other evidence for the period.

Ivory sources and trade

If availability of elephant ivory is hard to gauge, the ultimate sources of the material are even more problematical. The two possible candidates are Africa or Syro-Palestine, with the species Loxodonta africana and Elephas maximus asurus, respectively. Conclusive evidence in support of either has not yet been produced, although Syria, with some justification, has been regarded as the most likely source.

The distribution of the two species of elephant, if known, could, perhaps, give important clues as to the source of ivory found in Aegean contexts. Unfortunately, even in this field the evidence is scanty. P.E.P. Deraniyagala, a palaeontologist from Ceylon, who has produced several studies of elephant species and their distribution submits that the elephant had disappeared from Egypt by the pre-dynastic period, although surviving in the west until historic times when employed by the Carthaginians against the Romans.[86] Scullard attributes the disappearance of elephant, rhinoceros and giraffe from Egypt to a worsening climate and increased aridity during the I-IV Dynasties.[87] That Egypt was without local supplies of elephant ivory in pre- and early dynastic times may also be inferred from the wide use of hippopotamus tusk during this period.

The northernmost habitat of the elephant in Africa during dynastic times has not been established. However, at the time of writing (1955), Deraniyagala put the modern limits at latitude 15 degrees north, that is, the area of the Sudan near Khartoum. Egyptian trade with Nubia and areas to the south certainly existed in the Old Kingdom when luxury goods such as gold, ebony, ostrich eggs, resins and ivory were acquired. In the New Kingdom there are the well-attested expeditions of Queen Hasheput to the land of Punt with ivory as one of its goals.[88] At about this time the Egyptians may have been seeking additional sources in Syria. During his Asiatic campaign, Tutmosis I is recorded as having taken part in a great elephant hunt in the territory of Neya. Tutmosis III is said to have killed some 120 elephants, together with lions and wild cattle in the same district.[89]

Egyptian relations with the Aegean during the third millenium have aroused considerable debate, much of which is beyond the scope of this thesis. Objects of incontrovertible Old Kingdom date have been found in Early Minoan contexts and the find of a partially worked piece of hippopotamus tusk in EBA deposits at Knossos further supports the idea of trade links with Egypt at this time (below p. 70).[90] It is therefore possible, though not at all certain, that elephant ivory was also reaching Crete, via Egypt, during EMII. The discovery of the hippopotamus ivory may, however, cast doubt on the use of elephant ivory for EMII objects.

Connections between Crete and Egypt during the First Intermediate Period, the end of the third millenium, are less certain. The controversy centres around seal shapes, notably the button-seals thought by some to reflect Egyptian prototypes and stone vases considered by Warren to be Cretan imitations of Egyptian types current in the FIP and Middle Kingdom.[91] There is also the question of scarabs which may be used to support connections during this period. On the other hand, links with Syria during EMIII-MMIa are equally difficult to determine. Bronzes thought to show Syrian influence occur in Crete about this time, though no Minoan remains before MMII are known from the Levant.[92] Thus, if one rejects Egypt as a source of ivory during this period we have no assurance that it actually came from Syria. By the mid-second millenium the circumstantial evidence for Syrian origin of Aegean ivory does increase, especially with the evidence that the Egyptians themselves were exploiting this source.

It might be thought that the discovery of whole elephant tusks at Zakro or the carved tusk from chamber tomb 55 at Mycenae (ANM 2916) might help to resolve the question of sources. The latter is considered by some to have been carved before import to the Aegean which might point to a Syrian origin for the piece.[93] Opinion is not, however, unanimous and Hood believes 'the concepts and workmanship suggest that the carving was done by Aegean craftsmen.'[94] In view of such opposing interpretations, the tusk can have little value in our attempts to isolate the origin of Aegean ivory.

The Zakro tusks also present problems, although the excavator certainly believes them to be from the Syrian elephant, presumably Elephas maximus asurus.[95] This sub-species was defined by Deraniyagala in 1952 and so we cannot be certain that he would have assigned the Zakro tusks to this type. In fact, the identification of the sub-species rests on extremely thin objective evidence. That elephants did exist throughout the bronze age in Northern Syria, chiefly the Orontes valley, is not disputed. Actual finds of tusks, and more significantly, molars, are known [96] and the Egyptian records lend support. From a later period we have the evidence of Assyrian records and reliefs with the last recorded elephant hunt taking place ca. 859 B.C.[97] Opinions vary as to the survival of elephants in the area beyond this date. Barnett, followed by Hood sees them wiped out by overkill. Deraniyagala thinks they existed well into Roman times, although his arguments are by no means unassailable.[98]

As the name E. maximus asurus implies, this is taken to be a sub-species of the still extant Indian (Asian) elephant (E. maximus). Deraniyagala has based his identification on several palaeontological specimens, including molar and tusk fragments found by Woolley at Alalakh and two representations of elephants on contemporary monuments.[99] The most famous of these is the painting on the tomb of Rekhmire which shows a 'tamed dwarf' included as a part of the Assyrian tribute to Tutmosis III. Deraniyagala asserts that this beast is an 'undoubted Elephas maximus'. He does not present his reasons for this statement, although one may surmise that he is using size and shape of tusks as his criteria. In the modern species, tusks of E. maximus tend to be smaller and more curving than those of the African species. Also, the tip of the tusk is said to be flattened through wear unlike the African which is usually conical. According to Deraniyagala the Alalakh tusks show this characteristic of Elephas.[100] Unfortunately, the Rekhmire representations raise several doubts either ignored or skimmed over by the Singhalese palaeontologist. First is the issue that the beast is a tamed dwarf. Deraniyagala is asking us to accept not only a new species but he cites as his type specimen[101] one which, by his own admission, may be a dwarf and thus atypical. Dwarfism or nanism, is of course, attested among certain species, including the hippopotamus. It usually occurs where an animal species becomes restricted in small areas through geological or climatic changes as in the case of the Pleistocene dwarf hippopotami of the large Mediterranean islands (below p. 64 and n. 121). In the case of the Rekhmire painting Deraniyagala is assuming rather too much by presenting a dwarfed example as primary evidence for a non-dwarfed species, which elsewhere he asserts was larger than the modern E. maximus.[102] It should be pointed out that the beast cannot be a juvenile as it possesses well-developed tusks.

The other problem with the Rekhmire painting is the tusks carried in tribute. These, we are told 'doubtless belonged to the normal sized animals of the race but are larger than the ordinary E. maximus tusks of the present day.'[103] This confusion over tusk size and shape reduces greatly any hopes of identifying known tusks, such as the Zakro examples, on these criteria.[104] What Deraniyagala has not realised, or taken into account, is the nature of Egyptian art and the stylisation of representations which can occur. These paintings are not photographs but the impressions of artists who were bound by conventions and may well have not been working from life. Until the late mediaeval period all representations of elephants in England showed them as having hoofs similar to horses.[105]

If the definition of the _asurus_ sub-species by Deraniyagala rests on dubious criteria, there is some additional evidence to support the contention that the elephant inhabiting Northern Syria was not the African _Loxodonta_. First, there is the general principle that species or sub-species of fauna inhabiting Asia Minor and the Near East are more likely to be related to those of Asia proper than to those of sub-saharan Africa.[106] Secondly, there is a recently published note by D.A. Hooijer of the Natural History Museum, Leiden concerning the species of elephant present at Ugarit.[107] Hooijer reports on an elephant molar discovered by Schaeffer in 1960 at 125 W, point 2971, now in the National Museum in Damascus. He concludes:

> . . . the Ugarit specimen may be safely referred to _Elephas maximus_, the living Asiatic elephant. At present this species does not range westward beyond India, but in early historic times, its range extended to the Syrian desert. The present specimen, therefore, is the westernmost record for the living Asiatic elephant known to date. (108)

An evaluation of the foregoing evidence leaves us with the fact that elephants did inhabit the northern part of Syria from at least the mid-second millenium to the ninth or eighth centuries B.C. with possible extensions to the time range backwards and forwards. It is probable that these elephants were of the Asiatic variety rather than the African. Further, it is possible that a distinct sub-species of _E. maximus_ is involved.

The need to establish what sort of elephant did live in Syria has been alluded to above. Unfortunately, as the preceding discussion shows, the palaeozoological evidence is not sufficiently precise, at present, to permit a definitive statement about the origin of the Zakro tusks, much less worked Aegean ivories. Yet only the zoological grounds can offer a truly objective decision on the origin of these tusks and any which may be found on Aegean sites in the future. The ivory itself, when worked, offers little or no scope for identification of origin. Although there is some difference between the ivory from Asian and African elephants, the latter being slightly more translucent, Penniman states that this factor is not sufficiently strong to be of use in distinguishing the two types of ivory in fresh sections.[109]

Conclusions

Thus, because of the confusing nature of our evidence, both historical and palaeozoological, we cannot progress very far in our determination of the source or sources of elephant ivory worked in the Aegean bronze age. At present, circumstantial arguments and not scientific proof, provide us with more clues. For the EBA, when quantities were relatively small and connections are attested with Egypt, it is possible that African ivory, traded via Egypt, was that used. For the second palace period, the Zakro tusks and the bulk of ivory used in Mycenaean palace complexes, Syria is a more likely candidate. Elephant herds are, at least, well attested there from no later than ca. 1500 B.C. even if the species is still uncertain. The Egyptian exploitation of these sources suggests that African ivory was not sufficient to meet their own demands, much less those of the Aegean. We need not end this summary without hope. More careful examination by suitable experts of our existing tusks, both from Zakro and the Near Eastern sites of Ugarit, Alalakh and Megiddo could further elucidate the issue, perhaps assisted by further discoveries. For the present, the Aegean archaeologist should exercise restraint before boldly asserting that his ivory is of Syrian origin.

HIPPOPOTAMUS IVORY

That the tusk of hippopotamus may have provided a source of ivory in the Aegean bronze age has been ignored hitherto in the literature.[110] Perhaps this is not surprising as, until now, there has been no direct evidence for hippopotamus tusk on Aegean sites. I confess that at the start of this research I had given the matter little thought, especially as in small worked pieces it is virtually impossible to detect any difference between that and true elephant ivory. I am pleased to be able to present for the first time, evidence which suggests that hippopotamus tusk may well have contributed to ivory sources of the bronze age Aegean.

The Mycenae specimen

During March 1978 I began preliminary work on the collection of bone and ivory objects recovered from the Anglo-Hellenic excavations at the Citadel House, Mycenae, under the direction of Lord William Taylour. The objects are now housed in the Mycenae apotheke in Nauplion. Among the pieces of large unworked or partially worked ivory, was a large segment of tusk (see pls. 27, 28a; colour pl. I). As mentioned above in connection with the Mycenae workshop issue, this was described in preliminary reports as a 'large piece of elephant tusk' (n. 85 above). The shape and pattern of enamel on the surface indicated at once that it could not be from the elephant. Assisted by photographs in Penniman,[111] I was able to make a preliminary re-identification of this piece as hippopotamus lower canine (see fig. 10 for sketch of hippopotamus skull). Further study of the literature on hippopotamus and examination of the tusk again in July 1978 supported this supposition. I received final confirmation in December 1978 through correspondence with Dr. R.M. Laws, a recognised expert on the dentition of hippopotamus. Working from my photographs he did not hesitate to comment:

> . . . the piece conforms to tusks of modern _Hippopotamus amphibius_ in my own collection, the enamal pattern is characteristic, and the shape indicates the lower canine of the animal . . . (112)

The piece is approximately one-third of a lower canine, distal end, badly burnt by fire, but apart from the enamel beginning to flake off, is in good condition. The piece has not, to my knowledge, been conserved in any way. It is hoped that this will not be necessary, although there are signs that the flaking of the enamel is progressive. It weighs approximately 253 grams and has the following dimensions: L.pres. 0.16 m., Th. 0.04 m., W. 0.07 m.

Superficially, the discovery of this tusk points to the use of hippopotamus ivory as an additional source of the material at the Citadel House. There are, however, certain features of the tusk which require further examination before we may be permitted this conclusion. First, it is not possible to be entirely certain that this piece is fresh hippopotamus ivory. There are no definite traces of working and yet no further pieces of the tusk occur in recognisable form either in the room where it was found or elsewhere on the site. How we come to have only one-third of a tusk, and that apparently unworked, is slightly puzzling. Furthermore, its physical appearance and weight have led Sebastian Payne, who examined it in June 1979, to suggest that it might be fossil hippopotamus tusk. Originally we believed that the piece displayed little graining on the inner side (see pl. 27b) and its general texture might suggest some form of petrification. Moreover, a small 'bulb of percussion' has appeared in the centre of the tusk. Between March and July 1978 this bulb worked itself free, leaving a small circular depression (compare pl. 27b taken in July 1978 and pl. 27c taken in March 1978). According to Payne, all these features tend to indicate fossilised rather than fresh condition.[113]

Recently through the kindness of Dr. Laws, I have now obtained a hippopotamus lower canine for my own collection. The specimen is from a mature animal and clearly displays the principal characteristics of hippopotamus tusk, including the wear at the distal end and ridged enamel (see colour pl. II). It therefore offers an excellent comparison for the Mycenae example. Of utmost importance is however, the fact that quite naturally, through effects of change in environment, humidity and with time, the tusk has split in almost precisely the same fashion as the Mycenae tusk. (colour pl. III). The interior grain of the tusk is definitely similar to that displayed on the archaeological specimen and even the minute pattern along the very edge of the tusk (not clearly visible in photographs) is present in both pieces. The rather 'petrified' appearance of the Mycenae tusk might simply be due to the 'natural kiln effect' of intensive burning in limestone conditions on the Citadel.[114] Why only a portion of the tusk was present on the site cannot yet be answered.

We cannot, however, avoid the possibility that the tusk was not freshly imported to Mycenae, but that it was and is an example of fossil hippopotamus lower canine. At present it is unlikely that it will be possible to secure any objective scientific information as to the age of the tusk to assist in more precise identification. One scientist has indicated that any attempt to acquire a C 14 or other objective dating for the piece is likely to be totally destructive.[115] As this cannot be contemplated I have not attempted to pursue the scientific side much further for the purposes of this study. Recently, however, Dr. C. Forbes of the Sedgwick Museum of Geology, Cambridge, has suggested that the fission track dating method might be applied to some fragments of the enamel, leaving the rest of the tusk unharmed.[116] These questions will be considered further before preparing the piece for final publication.[117] For the present we must once again rely on circumstantial evidence for the origin of the piece.

If the tusk is indeed fossil, as opposed to petrified, a whole series of problems is raised. This would mean that the tusk came from <u>Hippopotamus amphibius antiquus</u>, the Pleistocene ancestor of the modern hippopotamus. In terms of size, <u>Hippopotamus antiquus</u> was somewhat larger than its modern descendant. The Mycenae tusk could be from either, depending on the age and size of the particular animal.[118]

<u>Hippopotamus amphibius antiquus</u> (Desmarest, 1822), also known as <u>Hippopotamus major</u> (Cuvier, 1824) first appeared in

European contexts in the Villafranchian. It spread throughout much of western Europe as well as southern Europe during the Pleistocene. Like the modern hippopotamus, antiquus was an herbivorous mammal, feeding on grass and aquatic plants such as found in most swampy conditions.[119] During the Pleistocene in Greece such conditions seem to have existed in the Megalopolis basin of the Peloponnese and probably the Peneios basin in Thessaly. Quantities of Pleistocene fossils were discovered by chance in the Megalopolis region in the early 1900s and subsequent excavations yielded remains of Elephas antiquus (mammoth), mastodon, rhinoceros and hippopotamus, to name but a few. The deposits were laid down over a considerable time span encompassing various climatic changes which account for the types of species found.[120] As yet there is no evidence to suggest that Hippopotamus antiquus inhabited the Pleistocene Argolid.

Hippopotami also existed on the large Mediterranean islands during the Pleistocene. On Crete there lived Hippopotamus creutzburgi (Boekschoten and Sondaar, 1966), while on Cyprus existed Phanourios minor (Boekschoten and Sondaar, 1972) named after a saint whose 'bones' are revered at the chapel of Ayios Phanourios near Ayios Georgios on the north coast. The bones in question are those of a dwarf species of hippopotamus.[121] These extinct pygmy species need not concern us regarding the source of the Mycenae tusk owing to the distribution and size of the animals. A lower canine of Phanourios minor which I have handled is similar in size and shape to a large boar's tusk. I understand that the tusks of the Cretan pygmy species are similar.[122]

If the Mycenae tusk is indeed fossil we must attempt to explain how it arrived in a LBA context some distance from the Pleistocene distribution of the animal. To do so we must suppose that the piece was discovered either in the Megalopolis basin or at an unknown habitation site of ancient hippopotami. It was then retrieved as a curio and either transported by its owner or traded to Mycenae. Once there, it was brought into one of the houses on the Citadel where it was kept as a curio or even an object of 'ritual significance'.

Such a scenario, it must be admitted, may sound rather far-fetched. Nevertheless it should be pointed out that some parallels may be found for such treatment of fossil remains. On Crete bones of the dwarfed Cretan deer which existed during the Pleistocene are said to have been recovered by Sir Arthur Evans in a shrine at Knossos.[123] I have personally come upon fossil horn, also from Evans' excavations at Knossos, but provenance otherwise unknown (see Appendix IIa). In his account of the sanctuary of Artemis Agroteras, near Megalopolis, Pausanias mentions the existence of bones, too large to be human and thought to be those of giants.[124] On Sicily the bones and skulls of dwarfed elephants were taken by Empedocles to be the skeleton of the Cyclops Polyphemus. Finally, Boekschoten and Sondaar report that as recently as 1969 pilgrimages of religious nature continued to those cave deposits of fossil bones still held to be saints' bones by the locals.[125]

The circumstantial arguments to support the presence of a fossilised hippopotamus tusk at Mycenae are complex and not, I feel, wholly convincing. How much easier it would be if we could account for the condition of the tusk by straightforward archaeological phenomena. This would require, first of all, the assumption that the tusk (of the modern species) was imported to Mycenae for use as ivory in the workshops. Or was it kept as a souvenir? The presence of large partly worked blocks of ivory in the Citadel House itself does indicate that somewhere nearby ivory-working on a considerable scale was taking place. A certain variety of ivory in its natural state would not be entirely surprising. Admittedly most of these partially worked pieces were found in the shrine-cum-storeroom near the Temple, some distance from Room II where the tusk was found. In that same room only small finished inlays of standard Mycenaean type, for example strips, rosettes and lilies, were recovered together with seven unworked boar's tusks (also below p. 286). If the hippopotamus tusk was due to be worked, as the excavator believes, why was it in Room II? A workshop area of some kind has been discovered nearby, but it must be stressed that the evidence of the ivories themselves gives little support to the conjecture that ivory working per se occurred either in Room II or its vicinity.[126]

Were it not for its apparently petrified state I think we could be fairly sure that the tusk was intended for use in ivory working processes somewhere in the Citadel House area. The destruction by fire of the site at the end of LHIIIb does seem to be a feasible explanation for the tusk's present condition. Certainly a number of ivory and bone objects from the Citadel House occur in advanced states of burning (below p. 104 ff). One or two have even created initial difficulties in their positive identification as ivory or bone due to the effects of high temperature and such may well be the case with the tusk. Unfortunately, none of the other bone or ivory objects in that particular room seem to have been affected at all.[127] True, these were scattered on the floor some distance from the tusk itself [128] and thus may not have been near enough to the source of heat to cause noticeable physical mutations. A preliminary study of the distribution of the highly burnt ivories at the Citadel House does suggest that exposure to burning on the site was highly localised. Further analysis of the finds and collaboration with other members of the Mycenae team will be needed before we can be wholly satisfied with this explanation for the hippopotamus tusk.

On the whole, I feel that petrification of fresh tusk may, in the end, prove to be the correct interpretation of the evidence. This is my own view now, and I would willingly revise it were firm evidence discovered to the contrary. The identification of the true nature of the tusk took place but two years ago and the fact is still largely unknown. I hope that a preliminary notification of the discovery will generate discussion with a view to increasing our knowledge about the piece before it appears in the final publication for the Citadel House.

Sources of hippopotamus ivory

For the present, let us continue to assume that petrification of the piece occurred through exposure to burning and high temperatures. Certainly there are some indications that the peculiar surface texture does not occur throughout the piece.[129] In addition the presence of a fresh hippopotamus tusk is not wholly inconsistent with the other ivory remains from the site; indeed, one piece discussed below (p. 75) might even support it. Nor is the import of hippopotamus tusk impossible to suppose in the Mycenaean period. As shown above, elephant ivory must have reached the Aegean by means of trade from the Syro-Palestinian coast or Egypt. Other precious materials, ostrich eggs and lapis lazuli were also traded via the same areas. Hippopotamus tusk, for use as ivory, may well have followed similar routes.

In some ways hippopotamus tusk may have been even more readily available than elephant ivory. The animal was probably quite widespread in the swampy areas along the Nile during dynastic times, unlike the elephant. Indeed, the hippopotamus still inhabited parts of the Nile delta until several hundred years ago when hunting, expansion of human settlement and the destruction of suitable environments contributed to its disappearance.[130] In dynastic times, the god Seth is represented on tomb reliefs as a hippopotamus and hunting and harpooning the beast is also attested. The latter appears to have been closely associated with the safety of the Egyptian monarchy as a papyrus of the Hyksos period records.[131] Slightly modified hippopotamus tusks, especially the rounded incisor teeth, are known from a number of graves of the Amratian and Gerzean cultures, usually with incised decoration.[132] The use of hippopotamus tusk, including the lower canines, continued into dynastic times, frequently in the form of ivory clappers and wands which closely follow the natural shape of the tusk. This fact allows for relatively easy identification of the source of the ivory.[133]

The incisors were particularly useful in the carving of ivory mirror handles, such as one in the shape of a lotus stem of Middle Kingdom date from Thebes.[134] Its use for smaller objects including pins and combs may also be supposed. In fact, its extremely dense structure (below p. 73) renders it even more advantageous than elephant ivory for such objects. Hippopotamus tusks, therefore, seem to have accounted for a considerable amount of the carved ivory found in dynastic contexts. As a locally available material it would have had many of the advantages of bone without the restrictions of size. While elephant ivory might have been more easy to acquire in Egypt than in the Aegean it was nonetheless an import.

Egypt is the most likely source of hippopotamus tusk found in Aegean contexts. The distribution of the hippopotamus is, however, not fully documented for the bronze age and it is possible that swampy areas in Syro-Palestine also supported small colonies of the animal in prehistoric times. Hippopotamus antiquus is well attested from this area in the Pleistocene: being recorded at Mount Carmel, the upper Jordan and Syria.[135] It had been thought that it disappeared completely in the faunal break occurring between the Upper and Lower Levalloiso-Mousterian levels. Quite recently concrete evidence to support the theory that hippopotami may have survived this break in Syro-Palestine has come to my attention. In a study of the animal bones from excavations at Tel Qasile, near modern Tel Aviv, G. Haas has discovered hippopotamus remains in levels ranging from Early Iron Age Ib (12th century B.C.) to the 5th century B.C. It should be stressed that the finds include the bones of the hippopotamus, not merely tusks, indicating the actual presence of the animal and not trade. Haas has suggested that the biotope appropriate for hippopotamus habitation continued in the swampy areas surrounding the site from the Pleistocene to subrecent times.[136] Of course the occurrence of hippopotamus at this site post-dates the Mycenae tusk by perhaps as much as a century. The conclusions reached by Haas nevertheless, do permit us to consider Syro-Palestine a possible alternative to Egypt as a source of hippopotamus ivory in the Aegean.

The Knossos specimen

The Mycenae tusk with its accompanying difficulties of origin cannot alone support the contention that hippopotamus teeth were being imported for use in Aegean ivory working. Most importantly its existence did alert me to this possibility. I did not really expect to obtain any conclusive proof. However, just one week after re-examining the Mycenae tusk in June 1979, I came upon a second indisputable piece of hippopotamus tusk at Knossos. I found the specimen, quite by chance, among the worked bone lots from Professor J.D. Evans' excavations in the West Court which took place in 1969.[137] In many ways this piece (see pl. 28b, c; colour pl. IV) is even more important than the Mycenae tusk, as it is indubitably worked. Its shape is irregular, measuring roughly 0.045 x 0.045 m. and is ca. 0.005 - 0.01 m. thick.

As with the Mycenae tusk, the key to identification was the ridged enamel outer layer which on the Knossos piece shows definite traces of working. Since enamel is very much harder than the ivory beneath (below p. 73), the initial stages of working hippopotamus tooth can be difficult. In this case it appears that abrasion was being used as a means of removing the enamel, but that the process was not completed. One end shows additional signs of working (pl. 28c). The cut is not clean but suggests partial sawing and splintering.

Still more exciting is the context of this piece. It was found in level BB 2, a level just below the paving in the West Court and according to the excavator represents fill in the EMIIa building which was uncovered there. In view of its significance I shall quote in extenso Professor Evans' comments on the building and its fill:

> The building itself was dated by a series of reconstructable pots found at floor level, but the fill above contained material of various phases down to EMIII (though only a few sherds of this were found and most of the material at all levels was EMII).

Professor Evans continued:

> Level BB 2 was no exception, containing EMII material along with EMI and a little Late Neolithic (no EMIII). While it is therefore impossible to be certain that it belongs to any one of these phases, my guess would be that it is probably EMII. I doubt if it can be any later. (138)

This discovery of a worked, yet identifiable piece of hippopotamus tusk in a reasonably secure EBA context at Knossos cannot be underestimated. First, it may serve to bolster up the theory that the unworked segment of tusk from Mycenae could be a fresh import.[139] In addition it appears in a Cretan context at a time when other Egyptian imports were appearing and when initial steps were made in ivory carving. It certainly raises the question of whether any EMII-MMIa seals were made from this material.

Structure and properties

Given this evidence for the use of hippopotamus tusk in the Aegean we may now examine more closely the characteristics of this material and its suitability for carving. The discussion will centre on the lower canines as both Aegean pieces are from that tusk, but there is no reason why other hippopotamus teeth, the large lower incisors, or the upper canines could not have been used as well. The basic nature of the material, its dentine and emamel are the same in all cases.

A possible drawback to the extensive use of hippopotamus tooth is the size and shape of the material available for carvings. An average lower canine can be twenty inches long and weigh some two and one-half pounds, although Penniman states that he has seen some tusks weighing as much as five or six pounds.[140] It will be remembered, however, that much of the ivory carving found on Aegean sites is in the form of small inlay plaques, buttons, knife handles and seals. Only the largest three-dimensional sculptures, furniture decorations and possibly some relief plaques would have been beyond the scope of hippopotamus lower canines. Furthermore, the smaller size of tusk might have been an advantage in long distance transport.

The shape of the lower canine is trihedral, similar to a boar's tusk. A triangular root canal exists at the proximal one-third of the tusk and there is an oblique wear facet at the distal end. This feature which may be noted on the Mycenae tusk and my own specimen (pls. 27a, 26a; colour pls. I, IIb) is similar to the wear facet on boar's tusks (cf. pl. 14a). The shape of a hippopotamus lower canine would not, I feel, have presented any difficulty for most Aegean ivory carvings. In fact Ritchie in his book on ivory carving remarks of hippopotamus tusk: [141]

> The large lower teeth make ideal slabs for bas relief, or cut-outs or diptychs, indeed they are highly suitable for anything flat, provided that is, they are cut in the right way . . .

He also states that one modern use of hippopotamus teeth is the carving of ivory chessmen.[142]

Another difference between the tusks of hippopotamus and elephant is the nature and thickness of the enamel. In hippopotamus it forms a distinctive pattern of deep ripples rather like a sandbank [143] on the outer surfaces of most teeth. It is extremely hard: 7 on the Mohs scale, comparable to jade or the fine gemstones carved on Aegean sites. On stale tusks this will crack and split off easily as seen on the Mycenae tusk (see pl. 28a for close-up) but on fresh ivory, it will, according to Ritchie, present some difficulty to the would-be carver. Perhaps this fact prompted the carver of the Knossian piece to try abrasion as a means of removing the enamel.

Beneath the enamel, hippopotamus tusk is composed of dentine just as is elephant ivory. Its microscopic structure is, however, somewhat different. The minute tubules of dentine extending outwards from the pulp cavity are, in the hippopotamus, only 1/14,000th inch in diameter at the base as opposed to 1/1,000th in elephant ivory.[144] This accounts for the hard dense structure of hippopotamus ivory which is said to be highly prized by carvers. On account of this extremely compact structure, the striations visible to the naked eye in elephant ivory do not occur in hippopotamus tusk. It has a much whiter appearance and takes a very high polish, largely due to these characteristics of the dentine.[145]

According to Penniman, hippopotamus lower canine in longitudinal section under magnification displays long thin parallel lines in the outer dentine and a rippled or wavy effect in the inner dentine. He claims to have seen this rippled effect on several carved ivories.[146] It should therefore be possible to use this as a diagnostic test to differentiate between hippopotamus and elephant ivory. As will be shown below in the matter of bone and ivory identification the all-important factor is expertise, acquired through extensive handling of pieces of known origin and gradually applying this to small, heavily worked pieces. So far I have had rather limited practice in this area, partly due to difficulties in acquiring samples of the raw material for study and experimentation.[147]

It is also difficult to confirm Penniman's statement from my own experience with Aegean ivories. There are several pieces from the Citadel House, Mycenae, which after prolonged examination and discussion Sebastian Payne and I have decided might have been carved from hippopotamus rather than elephant ivory. The grounds were not, however, so much the definitive recognition of peculiarities of hippopotamus ivory, but the absence of characteristic features of elephant ivory. This was confirmed in a recent conversation with Dr. C. Forbes of the Sedgwick Museum of Geology in Cambridge who admits there are difficulties in precise identification of ivory types. I have learnt that for all his experience, he finds it is far easier to state that something is not elephant ivory than to make a positive assertion in favour of hippopotamus.

One piece from the Citadel House caused particular difficulty: (74: 35) a large cylindrical object in unfinished state (pl.112). The lack of any lamination lines peculiar to elephant ivory led me to believe that the object was carved from bone, as first identified after excavation. The prime difficulty lay in its size: L. 0.097 m., diam. 0.021 m. No bone in fact exists which could yield an object of that size and according to Payne the thickness of solid material is greater than could be provided by cow or wild ox by a factor of two.[148] Although heavy tool marks may be obliterating the laminations characteristic of elephant ivory, a cloud or ripple pattern of graining can, in fact, be detected. Furthermore, it should be mentioned that apart from pieces badly disfigured by burning, virtually all pieces of ivory from the Citadel House reveal the usual laminations. Many, whether they be blocks or small plaques, have actually split along these lines and required conservation as in the case of Plate 17c. By process of exclusion it might be possible to describe the cylindrical piece, very tentatively, as hippopotamus ivory.

A large inlay strip (56c: 40) from the Citadel House also displays a ripple pattern on its highly polished upper surface. Here too there is no pattern of laminations or splitting as might be expected from elephant ivory. The cloud and ripple pattern accompanying a dense texture and highly polished surface is also striking on a number of the inlay plaques from the Royal Road ivory deposit at Knossos. These pieces, both small inlay squares with pegs and plano-convex plaques, are all astonishingly well-preserved (see pls. 3c, 21b, c, Type 56a and b). Almost all are intact and where breakage has occurred it is not along any definite pattern of laminations. These may be compared with the peg wedges where splitting may clearly be detected (pl. 48). Occasionally very fine and faint layers of dentine can be noted on the ends of the plano-convex inlays but they are not conclusive proof for the type of ivory. Where pieces have broken, the interior of the ivory is extremely dense and white.

At present I do not feel that there is sufficient evidence to identify the Royal Road ivories as made from hippopotamus tusk. Although we now have the EBA Knossian example I have not found a single piece of scrap or workers' waste from the ivory deposit which can be identified as hippopotamus tusk. More precisely, there are no waste pieces which bear the characteristic hippopotamus enamel, although certain identifiable pieces of elephant tusk with enamel do occur (above p. 40). One further search among the kilo or so of waste ivory might be worthwhile. Nevertheless the Royal Road pieces do present a problem and their appearance and physical state had puzzled me even before the issue of hippopotamus tusk arose. It is just possible that the plaques were made from hippopotamus tusk and the enamel was not recovered or I have missed it. A difference in type of ivory would be a welcome aid in explaining their appearance. But other factors, notably highly localised fluctuations in soil conditions, could provide equally compelling arguments. These might well account for the excellent condition of the plaques while other pieces from the same excavation have deteriorated or split.[149] Degree of polishing may also be a conserving factor. In general all Knossian ivories I have handled are characterised by their very pale cream colour, few signs of lamination lines and good condition. Few are discoloured tan to brown or splitting as those from the Citadel House, Mycenae. As for the 'cloud and ripple' pattern on the Royal Road plaques it may be nothing more than the way they were cut from the tusk (below p. 95), enhanced by conditions suited to their preservation.

Conclusions

It would, of course, be heartening to present conclusive evidence for finished pieces worked in hippopotamus tusk from Knossos or elsewhere in the Aegean to add further weight to the discovery of the Knossos and Mycenae tusk segments. It would be easy enough to convert suspicions of 'possibly hippopotamus' to 'probably hippopotamus' for several pieces I have handled. For the present, however, it is better to be satisfied with the indisputable evidence from Knossos and the more problematical tusk from Mycenae. It is hoped that with the discovery of these pieces both excavators and students of ivory carving will be alerted to the possibility that tusks other than those of the elephant may have provided the raw material for Aegean ivory craftsmen.[150]

The preceding discussion on the problems of differentiating between ivory types is a useful link to the following chapter which will examine the various criteria available for identifying bone, ivory and related materials when in worked state. It also concludes this general survey of the properties of the materials, their availability to Aegean craftsmen and their suitability for specific objects.

CHAPTER III

IDENTIFICATION OF THE MATERIALS

INTRODUCTION

An interesting aspect of the study of bone and ivory working in the Aegean bronze age is the correct identification of the materials used for particular classes of objects and individual items. Its importance goes beyond the general principal of scientific accuracy for its own sake. The correct identification of materials can help determine the interplay between suitability and availability discussed in the preceding chapter. The suitability of bone for pointed and blunt objects or of ivory for fine carvings is clear cut. Moreover in these cases rarely does the identification of material used present any difficulty. There is, however, a sizeable number of objects, including seals, small inlays and pins, where the precise relationship of suitability and availability is more difficult to ascertain. These three classes of objects are known in both bone and ivory; on occasion even boar's tusk or antler are substituted. Here, accurate identification may help to isolate the factors influencing selection.

Several examples may help to clarify the problem At the Citadel House, Mycenae, there exists a number of long bone pins with plain or decorated heads (Type 11a-c). A considerable amount of ivory was discovered on the site, both worked and unworked. Why are the pins not made of ivory? One of the most popular materials for carving seals in the Mesara was ivory. Some can now be re-identified as bone. Was bone used initially for carving seals and ivory only adopted at a later date when imports began? Or are the bone and ivory seals contemporaneous, with selection of material determined by personal wealth? The majority of both Cretan and mainland inlay plaques are certainly ivory, but some are unquestionably bone. Was there a disruption in ivory supplies, or were they to be covered in gold leaf and the material beneath of no consequence? Many of these questions cannot yet be answered, but at least accurate identification of materials permits them to be raised.

The differentiation between the materials in small worked objects is frequently difficult. The conditions of deposition, the effects of burning, even post-excavation treatment can alter the physical appearance of the materials in such a way as to impede easy identification. The most important asset in working with the materials is an open mind, together with a general knowledge of the physical properties of the raw materials. This chapter will explore those characteristics of greatest value for the purposes of identification. Two main areas of investigation will be presented: the macroscopic examination of shape, size and grain; and the microscopic study of grain and structure. The effects of high temperatures and the difficulties these raise for the recognition of ivory will be tackled. The discussion will centre on objects from three principal sources: the Lebena seals, the Royal Road ivory deposit and the Citadel House, Mycenae. A catalogue of all the bone and ivory seals from Lebena, setting out the criteria for their re-identification, appears as Appendix III.

MACROSCOPIC EXAMINATION

The initial stage in identifying the material used for a particular object is an examination of features visible to the naked eye. Three related aspects should be considered. First, the shape of the finished object may have been determined by the natural configuration of the material used. Second, the size of the object may have precluded the use of a certain material in its manufacture. These may be termed morphological criteria for identification. Finally, a macroscopic examination must consider those surface characteristics which reflect the structures peculiar to bone, ivory or antler. These may be easily recognisable features as cancellous bone, the enamel of boar's tusk or the ridged outer cortex of antler. Other characteristics of the surface - the grain of the material - are sometimes more difficult to isolate. These include the laminations of ivory and striations of bone and are the features which are generally most altered by deposition and exposure to high temperatures. Study of several, even all of these aspects may be needed to identify the material in a given piece. In addition to a general understanding of the morphological features of bone and related materials some experiience in handling unworked fragments is of great value for successful macroscopic examination.

Morphological Criteria

The shape of small objects such as seals and plaques is sometimes influenced by the natural configuration of the material used. This criterion is rarely of assistance in identifying elephant ivory since the size of tusks offers little hindrance to carving.[1] Occasionally the shape of an antler tine or portion of main beam is preserved in the finished appearance of an object (above pp. 29-31). Bone and boar's tusk, with their distinctive shapes when unworked, are, however, most successfully identified on these grounds.

Until now, no individual seals from pre-palatial Crete have been identified as boar's tusk [2], and only the Lebena group and a handful of seals from Kali Limenes have been published as bone. Nonetheless a number of seals can be positively identified as made from these materials on morphological grounds alone. The ring-shaped seals provide a fruitful line of inquiry. From Lebena, HM 1924 is a large and finely worked example of this type. In all, three morphological features, taken together, identify this material as bone and even allow precise identification as to the specific bone used. First we may consider the round shape of the seal in section, together with the diameter of the central hole (pl. 4a). This shape is suggestive of a transverse section of a long bone, the central hole being nothing more than the marrow cavity (fig. 2). The second feature worth attention is the V-shaped portion of solid material protruding into the hole. This might correspond to the septum dividing the marrow cavity in metapodials of ruminants (fig. 2e). Finally, on the outer surface of the seal, corresponding to the inner protrusion is a slight depression, oblong in shape (pl. 4b). Close examination reveals no sign of tool marks, that is, it is a natural feature of the material. Taken together, these characteristics point to a transverse section of a metapodial as the raw material used. The actual size of the seal and especially the diameter in section suggests cattle rather than sheep/goat; while the round section indicates metatarsal and not metacarpal (fig. 2e). The presence of these distinctive morphological features is specially felicitous since an examination of surface characteristics gives no sure indication of the material.

Other ring-shaped seals from Lebena have none of these striking features (see pl. 29a, b and Appendix III). They can be identified as bone, partly through surface features and partly by comparison of colour, texture and shape with HM 1924. Most are probably manufactured from transverse sections of metapodials, either sheep/goat or cattle, but are all much smaller and of a lower standard of workmanship than HM 1924. There is however, one curious aspect about the shape of these seals: a general resemblance to the distal condyles of metapodials, especially of pig or boar. Unfortunately while examining these seals I had no comparative collection to hand. Comparing actual samples of pig distal condyles with photographs some months later is a poor substitute. At least one faunal expert, however, agrees that these seals could have been made from such distal condyles.[3] Even if they were carved into that shape from transverse sections of diaphyses as HM 1924, it is interesting to speculate whether the inspiration for the shape may have been derived from a naturally occurring shape in bone.

HM 2005 from Lebena may also be identified by using morphological criteria. This seal is made from three separate pieces held together by small pegs. The outer section is a hollow cylinder into which has been inserted the handle portion which, at the base, is also a hollow cylinder. Finally, a small round piece has been driven upwards to fill the gap. The method of manufacture is illustrated in Figure 15 (see also pl. 30a, b). It is the outer cylinder which gives the most telling clues as to the material used. First the hollow cylinder shape itself, coupled with a natural depression (visible in pl. 30b and CMS II.1 no. 210) strongly suggests that the material is a metapodial. Again, the round rather than half-moon shaped section indicates a metatarsal, while the size suggests cattle rather than sheep/goat. Nor is the use of a third central piece difficult to explain as comparison with HM 474 from Ayia Triada will show. Here a similar technique of inserting the central handle has been used but without the final central piece. With age, the material has shrunk and the central portion no longer fits tightly. It was presumably to avoid this happening that the final section was inserted in HM 2005. Method of manufacture, together with certain morphological features have, therefore, provided the evidence for type of material used. Other seals of this shape (e.g. HM 450, 451, 452) are carved from a single piece of material and must be ivory. Such would not, of course, be possible from bone. The identification of HM 2005 on morphological grounds is fortunate as details of surface graining would have provided few indications as to material. The seal, though intact, has been burnt to a chalky white, with corresponding changes in physical structure associated with exposure to high temperatures (below p. 106 and Appendix III).

HM 2005 falls into the category of seals with 'removable centres' discussed by Platon in his article in Festschrift Matz,[4] although he does not consider this particular piece. He does, however, include a near parallel, HM 1065 from Platanos with traces of the central portion, probably a handle, remaining. Platon believes that such seals with the central section inserted separately were manufactured in that form and do not represent later repairs of damage. He stresses the difficulties of matching up designs had the central pieces been later repairs. This is a reasonable argument: such seal faces were almost certainly carved with the central section in place. The reason for a 'removable centre' is rather more difficult to explain. This Platon believes was to provide a kind of insurance against the improper use of the seal. Only with the central section in place were they usable. The explanation, in light of a re-identification of materials used, need not be nearly so complex. With only a few exceptions, all the seals discussed by Platon could owe their shape to the use of transverse sections of long bones, either metatarsals or metacarpals. The longitudinal depression on HM 1065 may well prove that this piece was carved from a metapodial.

Hollow cylinders, also discussed by Platon could likewise be easily carved from a section of long bone. HM 1046 and 1056 from Platanos, as well as HM 585 from Palaikastro, could, on the basis of shape of cylinder and central hollow, be made from cattle metacarpals. The irregular longitudinal splitting, together with cracks running parallel to the central hole in HM 585, is strongly suggestive of bone. Also in the photograph in CMS II.1 (p. 573) it appears that the interior of the cylinder is not homogeneous with the exterior as might be expected of ivory. If anything there seem to be traces of cancellous material.

Another group discussed by Platon includes HM 425 through HM 431 all from Ayia Triada. In all of these the central section is not present, that is, they are merely hollow cylinders with one seal face decorated. HM 585 and 601 fall into the same category. These should presumably be reconstructed along the lines of HM 2005 or HM 1065 with hammer-headed handles. Yet most extant hammer-headed seals, including the group in ivory from Ayia Triada (HM 450, 451, 452, 474) together with the roughly parallel pieces in steatite (HM 540, 541, 1014) are all carved from a single piece of material. They do not have 'removable centres.' If the hollow cylinders are indeed hammer-headed seals with their centres missing it seems curious that seals of the same type from the same site should be made in two different fashions: some carved of a single piece, others intentionally made with removable centres to insure against forgery. Surely it is more reasonable to suppose that the original shape of the material used has determined the method of manufacture, in order to produce the desired finished shape.

Among the seals discussed by Platon are several which cannot be classed as bone owing to their shape. These include the two examples from Viannos (HM 1700 and 1701) together with HM 1064 from Platanos. The latter is a low cylinder with a detachable central portion. This piece shows clear signs of being ivory on the basis of lamination lines (cf. photograph p. 312-13 of <u>CMS</u> II.1). It is difficult to explain the reason for a separate central section. The lamination lines show that it was cut from a different piece of ivory, or at least in a different plane. Could it perhaps be a repair? The design on the central portion of the seal face does not actually link in with that on the outer cylinder. True, both bear concentric circles and dots, but there is no reason to suppose they must have been carved at the same time. The Viannos seals present a greater problem. It is clear that the detachable portions were carved at the same time as the rest of the seal face. HM 1701 with a horse-shoe shaped segment is certainly made from ivory as close inspection of the CMS photographs will reveal. This looks to me as though a repair was necessary through fracture of the ivory during manufacture which would explain the position of the peg holding the removable piece in place. It is clear that the peg was in position when the carving of the seal face occurred. If it had been the intention to remove the peg to take away the detachable section, it is highly unlikely that a line of incision would have been made right through the pin head. This would greatly weaken the pin, which would be liable to split through completely were it tampered with. It is interesting to note that on HM 2005 which I have handled, there is no indication that once carved the pins or separate sections were removed or tampered with in any way. If these pieces really were carved for the purpose which Platon suggests, some signs of removal and replacing of pegs would be expected. By considering the alternative use of bone for seal manufacture and by admitting the possibility of repairs during manufacture of ivory seals we may conclude that Platon's theory regarding 'removable centres' is no longer wholly acceptable.

Morphological characteristics of bone have therefore assisted in reconsideration of both ring-shaped and hammer-headed seals. Similar tests may also be applied against a third group, the 'epomion' or shoulder-shaped seals. These exist predominantly in 'ivory' although a very few seals of approximately the same shape and possibly the same inspiration were also made in steatite. Eighteen examples of this type made in 'ivory' are published in CMS II.1, while a further five, one bone and four 'ivory' are published from Kali Limenes in CMS IV.[5] The general shape and size of these seals could have been produced from a portion of long bone, either metatarsal or tibia. This is offered more as hypothesis to be tested rather than hard fact since I have handled only one example of this type and studied others in cases or from photographs. The Ashmolean piece[6] (1968-1844) is bone, but of unknown provenance. The three examples from Ayia Triada (HM 489, 503, 504) bear no distinguishing surface features which would assist positive identification as ivory, nor does HM 1212 from Marathokephalo. HM 1213 from that site, may on the basis of shape alone be tentatively re-identified as made from a section of metapodial; while both shape and surface features of HM 1211 are also strongly suggestive of bone. From Platanos, both HM 1054 and 1057 could also be bone, at least on the basis of shape and size. Macroscopic examination of surface structure is here rather more confusing than helpful: the cracking on HM 1054 could be found on either bone or ivory depending on conditions, although the former is marginally more likely. Of the series HM 1109 - 1112, all could be bone on the basis of size and shape; while surface graining is more akin to bone than ivory. The last two (HM 1111 and 1112) are especially convincing as bone, both from the photographs and when viewed in cases.[7] On the other hand, HM 1073 an elaborate variation of the shoulder seal from Platanos, with stylised animal head on the back of the handle is almost certainly ivory. Of course it is quite possible for a type to exist in both materials, as both the ring-shaped and hammer-headed varieties testify.

The material of one last group of Cretan seals may also be re-identified with considerable confidence. These are seals which display the morphological characteristics of boar's tusk. Tusks are roughly triangular in section near the root cavity but become somewhat more rounded toward the tip, excluding that portion with the wear facet (fig. 10b). Seals made from boar's tusk often preserve this triangular section which greatly assists in correctly identifying the material. Others are of the cone-shaped variety, approximately 2-3 cms. in height, well within the range of solid material available from a mature tusk (above pp. 33-4).

We may begin with a group of several seals which may be re-identified positively on morphological criteria alone. These include HM 434, 435 and 507 from Ayia Triada, which all have the characteristic sub-triangular section. HM 434 has carving on both seal faces, one of which is slightly larger than the other. This face also has a small triangular piece 'missing': in fact, the end of the root canal. Its 'absence' from the larger of the two seal faces is therefore correct. This hole may once have been plugged with a 'detachable' plate although there are no nail holes, nor does the carving on that seal face demand reconstruction with a central segment.

To the inexperienced eye, HM 507 is perhaps the most easily recognisable as boar's tusk. The sub-triangular seal face, carved in the usual lattice pattern, has a small triangular hole in the centre, again the last traces of the root canal. The remainder of the seal tapers to the top, becoming somewhat round in section. There are, in addition, several vestiges of enamel on the surface. An almost exact parallel is HM 526 from Koumasa, although here the base of the seal is solid. The height, 0.053, shows that the original tusk was fairly sizeable.[8]

Two other seals from Ayia Triada, HM 495 with sub-triangular seal face, and HM 476 with a small hollow in the seal face, may also be made from boar's tusk, although the grounds are not sufficiently strong to permit re-identification without first-hand examination of the objects. This is also the case with a number of cone-shaped seals. CMS II.1 no. 101-102 (no HM invs.) from Ayia Triada, HM 518 from Koumasa, HM 1072 from Platanos, HM 68 from Phaistos and HM 1577 from Trapeza could all be boar's tusk on the basis of shape and size, although I do not feel that these morphological criteria are quite strong enough to allow positive re-identification without actually handling the objects. In the case of HM 518 from Koumasa a consideration of surface graining is an additional clue to the possible use of boar's tusk for the piece; while the shape into which HM 68 from Phaistos has been carved is remarkably close to a portion of partially worked tusk from Ayia Irini (above p. 34 and pl. 15b).

The examples above all illustrate the value of understanding the natural configuration and morphological features of the materials for identification. Occasionally the question of size may also be of assistance in determining material used. This tends to provide negative evidence: excluding the possible use of bone or boar's tusk in place of ivory, rather than a conclusive test for their use. Moreover, the size of boar's tusks may vary considerably, as can the thickness of solid bone, depending on maturity and sex of the beast.

It should be clear from the foregoing discussion that morphological features of a piece alone cannot always provide sufficient evidence for identification of material used. Many of the areas of doubt indicated above could be resolved by closer examination of surface grain or structure, or even by microscopic examination. It can, however, be useful to isolate in advance of more detailed first-hand examination, those seals which would most benefit from such treatment. Here, a careful consideration of seals and other objects which, on morphological grounds, could be bone or boar's tusk rather than ivory, might be most instructive.[9]

Surface characteristics

A useful method for approaching the question of surface characteristics is to begin with the immediately recognisable and positively definitive features. These include the presence of spongy or cancellous bone, sometimes accompanying the vestiges of a marrow cavity; the spongy material found beneath the hard outer cortex in antler; and traces of enamel on boar's tusk. The enamel of ivory, while distinctive, is almost never preserved on a finished piece, although as discussed above (p. 40, pl. 20b) it is found on several pieces in the ivory workers' deposit at Knossos. The best way of learning to recognise these features on pieces of unknown material is to observe them both in unworked fragments and on objects over which there is no question: for example the underside of rib bone implements (Type 12) and the surface of boar's tusk helmet plaques.

The presence of cancellous material on the underside of some Cretan inlay plaques has been mentioned above (p. 13, pl. 3a). This alone provided sufficient evidence to identify the material as bone. Cancellous material together with vestiges of a marrow cavity may also be seen in another small plaque from Knossos (pl. 31a, centre). The accompanying pieces are ivory and this plaque, when viewed from its upper surface shows little appreciable difference. Another Knossos example which could have been considered ivory is illustrated on Plate 31b and c. Viewed from the side (pl. 31b) this looks like a clear example of ivory splitting along laminations. The underside is, however, a sure indicator that the piece is bone.

In the case of antler, identification of the material is usually immediate. I have rarely found cases of serious mis-identification nor have encountered major difficulties myself.[11] This is largely due to the fact that the surface characteristics are so distinctive. First there are the remains of the marks left by blood vessels on the outer cortex which are usually preserved on the surface of antler implements (pl. 12a, b). Second, there is the cancellous material within the compact outer layer. This cancellous interior is completely different from that usually seen in connection with bone (compare pl. 32a and pl. 10). Since it runs throughout the centre of all antler, most objects made from this material bear considerable quantities of it. It looks and feels extremely porous, the holes being quite uniform and round, rather like a cheap commercially manufactured sponge. The traces of cancellous bone which are usually preserved in worked pieces are much harder material, often leaving irregular, elongated ridges, more in the manner of natural sponge. Extremely porous cancellous bone does exist as a photograph of the interior of a distal condyle shows (pl. 32b). This portion of bone would, however, rarely be encountered in any object necessitating identification of material.

Cancellous material of antler has occasionally provided clues for identifying the material, as shown by two pieces from Ayia Irini mentioned above (p. 30). The figure-of-eight shield (fig. 9c) retains traces of spongy material on the underside, although final identification was made on the basis of the surface grain; while the antler knob (pl. 13b) was identified partly on the remains of some cancellous material and partly on the finished shape of the object.[12]

Finally we may consider enamel as found on boar's tusk. The preservation of this surface feature on several small inlays from Kea (p. 33 and pl. 15a) confirmed them to be boar's tusk even though they do not conform to the usual helmet plaque shape. The enamel, combined with shape, provides a useful means of recognising the piece on Plate 108a (left) from Knossos as boar's tusk. Finally, the seal HM 1576 from Trapeza not only possesses a sub-triangular seal face with small hollow, is cone-shaped in profile, but even has traces of enamel to confirm positively the identification as boar's tusk. The seal is described as an ivory conoid in CMS while in the original BSA publication it is rather more accurately called a tooth which has been left in approximately natural shape.[13] It is, of course, possible for some objects, including seals to be made from other large animal teeth which are all dentine covered with enamel. In the case of HM 1576, the configuration of the seal face requires identification as boar's tusk.

its corollary may single out pieces for consideration as bone. As mentioned above, enamel plays little or no part in the identification of the material, nor do the shallow black cracks near the tip of the tusk, interesting though it may be to have specimens from Knossos and Mycenae (above pp. 39-40; pls. 19, 20 and fig. 11a). Finally the lines of Owen, the celebrated "engine-turning" effect are rarely evident on pieces of ivory from the Aegean. Some traces may occur on one piece from the Citadel House although the marks could also be caused by stains (pl. 110c). Besides, there is no question that this piece is ivory. This leaves us with one main source of sure evidence for identification: the laminations or growth rings. These should appear as rather finely spaced lines, absolutely parallel, often a little darker or lighter than the rest of the ivory. The actual pattern of these lines depends largely on how the object was cut from the tusk. They may appear in concentric circles as in the large cylinder seals HM 1042 and HM 1103 from Platanos. The size and spacing of these circles suggest the pieces were cut from a transverse section of elephant tusk, very near the centre of the tusk (cf. pattern of rings on pl. 18a). They may be concentric but ovoid as in Plate 48c, a peg wedge from Knossos where they appear lighter than the rest of the ivory. This piece was probably cut at an angle through the centre portion of the tusk. In yet other cases, notably the plano-convex plaques from Knossos (pl. 3c) the laminations are not so clearly visible. In Plate 33a (right) there is a ripply pattern of nearly parallel lines visible on the upper surface and the parallel lamination lines were just discernable in part of the section. Assuming this piece is indeed elephant and not hippopotamus ivory (above p. 75), it must have been cut longitudinally along the axis of the tusk. The plano-oonvex plaque illustrated with it has a much clearer pattern of laminations and is a rare example of splitting along them in this type of object. One other pieces, such as the Ayia Irini comb. (pl. 25a) the laminations merely appear as long parallel lines running diagonally across the object, indicating that it was probably cut from a flat, transverse section, all in one plane.

The pattern of laminations on larger three-dimensional objects can be quite complex according to the different planes of the finished pieces and therefore the angles at which they were removed from the tusk. This is illustrated by the underside of a large sword pommel from the Citadel House, Mycenae (43: 13, pl. 33b, c) as well as on a smaller scale by the pattern of laminations on a ring-shaped seal from Lebena (HM 1929) published originally as 'Bein' (pl. 29c). Here the grain is lighter than the rest of the ivory. Usually, it is not essential to determine what portion of the tusk provided ivory for a given object except when considering general questions of manufacture methods. For the purpose of re-identification, merely an awareness of the possible variations in the appearance of laminations is needed.

The real difficulty in using laminations as a means of identifying materials occurs in very small pieces, particularly if cut along the grain of the ivory so that few if any concentric growth rings are preserved in the finished object. Furthermore, if cut at angles to the grain as in the Knossos plaques, the lines may appear wavy and not particularly parallel raising doubts about the type of ivory used. In many of the Knossos pieces, the plano-convex end section is completely covered by tool marks so that it is impossible to 'follow' the wavy lines on the upper surface through to the end section. In other cases, if lines appear irregular it is possible to mistake pieces as bone.

Lamination lines provide lines of fracture along which an object may break, especially if subjected to maltreatment after excavation. If the object has not then been conserved, a useful means of verifying the material is provided. In the case of 70: 25 (pl. 34a), the upper section of the piece has split away, leaving clean fresh ivory beneath, very homogeneous in appearance. There are no other traces of lamination lines in this piece. The seals HM 1940 (unpub.) and HM 1973 from Lebena may also be identified as ivory on these grounds (see pl. 34b). The corner mouldings from Knossos have similarly split along regular lines (pl. 34c).

These clean breaks along laminations, as the visibility of the laminations themselves are, however, fortuitous and pieces should not be discounted as ivory simply because these features are not evident. There is also reason to believe that the manner in which a piece was cut from the tusk could reduce its proclivity to fracture. Thus, the plano-convex plaques and square inlays from Knossos have rarely split along laminations even though they may be otherwise damaged, for example broken corners. Certainly the incidence of fracture is far lower among this class of objects from Knossos than among any other from the ivory workers' deposit. On the other hand, ivory objects from the Citadel House, Mycenae have frequently split along laminations, except in a few cases where they are heavily calcified. It can be suggested that conditions of deposition and subjection to wide variation in humidity after excavation have produced their present state.[14]

Surface grain: bone

Before considering the effects of high temperatures on ivory and the ensuing alteration in its physical appearance we may first examine the normal surface grain visible in bone. The nature of its chemical composition and growth means that bone is a far less homogeneous substance than ivory. The principal feature visible is the nutrient foramina, fine tubes running lengthwise down the bone and containing organic material when the bone is fresh. According to Penniman [15], they provide the chief means of distinguishing this material from others. In transverse section of a long bone they may be visible as tiny black dots, while on the outer surface or in longitudinal section they may appear as fine black lines, known as striations. However, as a practical means of identification I have never found nutrient foramina in transverse section to be of any assistance. One might, for instance, expect to see them on HM 1924 from Lebena (pl. 4a) which is securely established as bone on other criteria (above pp. 81-2). Here tool marks obviate any possibility of seeing traces of the foramina while other pieces may be too badly damaged, or simply not carved from a portion of bone which would show these features. Foramina running lengthwise on the outer surface of an object are rather more reliable indicators of material. Unlike the laminations of ivory these are almost always a darker colour than the rest of the material but need not be black as Penniman states. They may be observed on long straight objects such as pins and should be just visible to the naked eye, although they do not often show up well in photographs (pls. 72-3 pins from Lerna).

Nutrient foramina are not, however, wholly diagnostic characteristics. As Plate 32a shows, they run roughly parallel to one another, although for fairly short lengths and rarely begin or end at the same point. Nevertheless, in small worked objects they may appear sufficiently parallel to cause confusion with the laminations of ivory. Furthermore, as indicated above, there can be no guarantee that those laminations will appear absolutely parallel in a finished piece.

Bone may also crack and split according to conditions of deposition and post-excavation treatment. In general, the splitting is along irregular, though roughly parallel lines. This may be observed in Plate 35a transverse section of cattle metatarsal which I have cut into the shape of a hollow cylinder seal and on Plate 35b. Similar cracks also appear in the shoulder seal HM 1054 from Platanos, a possible candidate for re-identification as bone. This cracking can, however, also occur in ivory as in the large ivory cylinder HM 1042 or the tongue-shaped seal HM 1048 identifiable as ivory by laminations running through the seal faces. Still more confusing from the point of view of making correct identifications are those cracks which can arise around the marrow cavity of a long bone. Sometimes two or three roughly concentric lines of fracture may develop (pl. 35a) which, if considered without reference to other criteria, may suggest identification as ivory. This feature may be seen on the upper surface of HM 585 from Palaikastro. On the whole the usefulness of these surface criteria is rather mixed. Laminations are the surest test that a piece is ivory, and occasionally nutrient foramina may be so clear as to allow positive identification as bone. Cracking and splitting along laminations or other natural lines of fracture are more difficult to apply unless they are of 'canonical' formation.

Other peculiarities of graining are even less easy to qualify than either laminations or foramina. These can sometimes be observed if a portion of the original surface of the piece is missing. Modern breaks, mentioned above, revealing interior of ivory are most obvious, but ancient breaks are also likely to reveal a distinctive interior. Another possibility is a series of layers which appear irregular when viewed from above. Bone which has suffered ancient breaks, particularly the removal of the outer surface of bone, may also appear layered (pl. 35b). The texture will usually appear far less homogeneous than the outer surface and might even seem porous with roughly elongated channels resulting from the configuration of the nutrient foramina. In this way it should be possible to distinguish bone from the more homogeneous ivory.

Yet another peculiarity of surface texture are 'root marks', which appear as small irregular grooves on the surface of the material, even penetrating into the material below. I have observed these most frequently on polished bone pins (see pl. 75b hooked pin from Knossos). Whether this is simply a peculiarity of deposition or in fact a diagnostic feature of bone is not clear, although I cannot recall observing this on ivory.

Apart from laminations and sometimes nutrient foramina, the other aspects of surface grain mentioned are not, in my view, alone sufficient evidence to permit positive identification of bone or ivory. They can be used only in conjunction with other tests, whether morphological criteria or microscopic examination.

Colour

A brief word may be devoted to the colour of objects made from bone and ivory. Rarely, if ever, is this a safe method for identification of material. Yet since colour is often the single most noticeable feature of an object there may be a temptation to devote too much attention to it. The colour of objects may be influenced by a number of factors including natural characteristics of the soil at the time of deposition; and presence of other substances, for example high organic or calcium content. Colour may be altered by the length of time taken for deposition: that is, the amount of exposure to the elements a piece received before being covered over. Was the piece bleached by wind and sun; partially eroded by sand? Finally, striking colour changes may have been effected by exposure to high temperatures over a prolonged time period, or by rapid burning. Several examples will illustrate the types of colour changes encountered.

Bone tools from neolithic deposits at Lerna tend to be darker in colour than those of subsequent periods, ranging from dark tan to chocolate brown and even black with highly polished surfaces. Banks [16] considered colour to be a secure enough criterion to 'date' bone tools from mixed deposits, especially from the House of Tiles fill. In fact, careful examination of bone tools from much later (i.e. Lerna IV and V) deposits of uncontaminated nature show that these dark brown to black colours occur from all periods, even though the greatest single concentration does come from the neolithic collection. Colour as a criterion for dating is therefore most unsatisfactory.

A few of the objects, whether bone or ivory, from the Citadel House, Mycenae, are what might be termed 'natural' ivory colour registering 5Y 9/1.5 or 10 YR 8/2 (white) and 10 YR 8/3 (very pale brown) on the Munsell scale. The majority of ivory pieces and many of the bone are in the Munsell range 5 YR 6/6 and 7.5 YR 7/6 (reddish yellow) or 5 YR 5/6 (yellowish red). Clearly colour differences are not associated with specific materials but with different conditions of deposition. The yellow or tan colour is generally regarded as a form of natural patination.[17]

Modern conservation methods such as PVA should not cause further discolouration of bone or ivory, although some of the substances used in the past may have caused objects to turn brown more rapidly. The only quantifiable changes in colour are those associated with exposure to high temperatures and occur in conjunction with physical changes in the materials. In such cases, however, the alterations in colour do not assist in differentiating between bone and ivory, but between these and other substances such as stone. On the whole, colour change may be regarded as a form of supplementary evidence, but is rarely central to the question of separating bone from ivory.

Effects of high temperatures

The colour of ivory and related materials, together with their physical structures, will undergo transformation when subjected to high temperatures and burning. The changes occur due to relative alterations in the organic and inorganic constituents of ivory.[18] Some years ago, experiments were conducted into the effects of high temperatures on ivory, under the aegis of the Conservation Centre, Institute of Fine Arts, New York and the International Institute for Conservation. The following discussion is an attempt to correlate their findings with extant pieces of ivory from the Aegean.

In the first experiment, samples of ivory were subjected to high temperatures for one hour at increasing temperatures from 149 °C to 871 °C. According to the report[19]:

> The appearance of colour in the samples is consistent with chemical alteration within the organic part of the ivory. This first produces a yellow colour, then increasing amounts of free carbon are formed within the ivory (brown -> black) followed by successively more complete combustion until no more organic matter remains (black -> grey-blue -> white).

The relevant tables have been reproduced here (Tables 4-7) to facilitate discussion.[20] In Table 4A it will be noted that colour changes range from light yellow (Munsell 2.5 Y 8/4 - 9/2) through brown, brown-black, black, dark grey-blue, light grey-blue to white (5 PB 9/1). A further series of tests were carried out with carbonaceous material (charcoal or wood) added to the sample to produce an oxidising atmosphere. A similar range of colours was obtained (Table 5) although at the highest temperatures light grey-blue rather than white was reached. In conjunction with the colour changes, alterations occured in the physical structure of the ivory as indicated in the same table. Many of these features may be seen in ivories from Aegean sites.

A further series of experiments explored the changes in physical condition and colour of ivory when heated for prolonged times.[21] The samples heated at relatively low temperatures (149 °C) for up to eight hours showed slight colour changes to light yellow but the structure remained intact (Table 6). Heating at 204 °C for up to twenty-four hours, the colours changed to yellow brown and only slight physical alterations were detected. The structure remained unchanged (Table 6). Otherwise the changes in colour and structure at higher temperatures were similar to those obtained during the one hour long experiments. The results may be seen in Table 7.

The scientists concluded that under a very narrow range of oven temperatures and times, the colour of ivory could have been changed without undue damage to the physical structure.[22] Whether such controlled use of temperature was ever intentionally employed to alter the natural colour of ivory, carved or uncarved, remains unanswered. Plenderleith has suggested that 'there seems reason to suppose that the burning (of some ancient ivories) was intentional and was carried out with the object of achieving a particular colour effect'.[23] At present, the evidence from the Aegean on this point is by no means clear. Some of the square inlay plaques from Royal Road, Knossos are burnt black to dark grey-blue and show very little structural deterioration. Whether this is evidence for controlled heating of ivory to produce plaques of varying colours or is simply fortuitous cannot at this stage be said. Only a small number of ivory pieces from the Royal Road deposit show traces of burning. Nevertheless, until a more complete account of the excavation is available it cannot be determined whether the colour of these plaques is the result of localised burning during the destruction of the site or a more intentional use of high temperatures.

Many ivories from the Aegean show traces of burning or the effects of high temperature. It is not, of course, possible to state categorically that a certain piece was subjected to certain temperatures for a set length of time based on comparisons with the results of the New York laboratory tests. Nonetheless, many of the degrees of physical alteration and colour change noted in the experiments will be seen on excavated samples from the Aegean.

Colour plate Va shows a mushroom-shaped object from the Citadel House, Mycenae (61: 24) brown-black in colour (10 YR 2/1) which seems to correspond roughly with the laboratory category C2 (see Table 5). The description 'checking' was difficult to isolate on this piece but there is clear evidence of a flaking surface and signs of splitting in the direction of the grain can also be observed. A similar state can be seen on the pommel (43: 12) with the addition of irregular network of fine cracks, the stage beyond simple flaking of the surface (see colour pl. Vb and pl. 37a, b). These networks of fine, irregular cracks also occur in a partially finished piece from the Citadel House (70: 30, pl. 37c) which ranges in colour from brown-black into dark grey.

One of the most striking illustrations of the effects of high temperature on colour and structure of ivory may be seen in a model dagger inlay from the Citadel House (61: 23) badly damaged but now made up in wax. The colour range is from light brown, through brown-black to grey-blue to light grey-blue. This would seem to suggest rather uneven temperatures and perhaps the proximity of free carbon at various stages during burning (see colour pl. VIa and pl. 104). Where the outer surface of the material approaches white (5 PB 8/1) especially at the hilt end of the dagger and on the underside, the ivory beneath ranges from light to dark grey-blue. This portion of the material is extremely friable and where not conserved with PVA is easily crumbled. Here the surface itself is covered by extremely fine irregular cracks consistent with the laboratory's category F3 (light grey-blue). Elsewhere, and roughly corresponding to the brownish areas, the ivory is flaking in similar fashion to the pieces discussed above.

The Knossos ivory plaques mentioned above give good examples of the colour range brown-black and blue-black (colour pl. VIb). However, these pieces show little sign of physical alteration. There are no fine cracks and no flaking of the surface; nor is there any suggestion that the piece is less sound structurally than the naturally coloured square plaques.[24] According to the laboratory findings, the presence of wood, coupled with relatively low temperatures did produce colours in the brown-black range with virtually no physical changes and with the structure remaining intact. The experiments as presented do not indicate whether by prolonging the heating time with continued presence of wood, the colour range would extend to blue-black and dark-grey-blue accompanied by no further deterioration of physical structure.

Cretan seals, including the group from Lebena, may also reflect changes in colour and structure of the material.[25] HM 1936 and 1928 have both been burnt brown-black with irregular flaking and splitting of the ivory along the grain (colour pl. VII and pl. 38a, b). In neither case do lamination lines appear in the canonical form, which might cause initial confusion in identification of the material. That the pieces are in fact ivory may be established by comparing the nature of the splitting in these seals with that seen on the pieces from the Citadel House discussed above, especially the sword pommel and mushroom-shaped object.

Colour plate VIIIa and b illustrates the dark grey-blue range of colour change in seal HM 2002. Fine irregular cracks appear on the front of the seal (colour pl. VIIIa and pl. 38c), together with some wider more irregularly shaped and spaced cracks. The material is not, however, friable, indeed its physical condition is remarkably solid, suggesting some degree of calcination in conjunction with the burning. Finally seal HM 1917 gives an example of an ivory seal burnt white with irregular splitting along the laminations. (Colour pl. IXa and pl. 39a).

Hitherto the discussion has centred on the effects of high temperatures on ivory rather than bone. Unfortunately, the New York experiments did not include the latter and as a result we have little scientific evidence to apply to the problem of burnt, worked bone objects in the Aegean. In the matter of colour changes, we should, however, expect to see a similar range as encountered for ivory since the chemical constituents of the organic portion are similar in both materials. It is not possible to be sure of the corresponding changes in physical structure. HM 2005 the hammer-headed seal discussed above (p. 83) is certainly bone, which has been burnt chalky white. The material is not in the least friable and has a texture similar to HM 2002 again suggesting calcination. The surface is however, covered with a network of irregular lines which may be a distortion of the foramina normally to be seen on the surface of a long bone.

A most curious effect of high temperature on bone/ivory may be observed on colour plate IXb a 'cosmetic spatula' from the Citadel House, Mycenae (28: 5). Here there are no distinguishing surface marks whatsoever: no traces of foramina, laminations; no networks of fine cracks or checking. The colour is blue, somewhat darker inside than out. The piece has an almost metallic ring to it, but after prolonged investigation, including deliberate breakage, it became clear that the piece was originally bone or perhaps ivory. The latter is less likely on two counts: first, few of the pins at the Citadel House are in fact ivory; and second, virtually all pieces of burnt ivory on the site do show traces of cracking, splitting or flaking.

The differences between the physical condition and colour of burnt bone and ivory therefore need further attention and support of scientific experiment. At this stage we can, therefore, add little definitive proof that a given material is bone based on its characteristics after burning. Features of burnt ivory are, however, now adequately understood so that by careful observation it should be possible to identify ivory pieces whose physical condition has been altered by high temperatures.

MICROSCOPIC EXAMINATION

The chemical composition and structural characteristics of bone, ivory and related materials are similar but not identical. These differences in structure outlined in the preceding chapter should, therefore, provide the most reliable evidence for identifying the materials when no clear indications are offered by macroscopic examinations of shape or surface features. By using a microscope it is possible, under certain conditions, to obtain the proof needed for the positive identification of material. Nevertheless, the microscope should, in my opinion, be used only as a last resort when other methods have been exhausted. Indeed, the arguments against the use of a microscope are almost as great as the positive benefits which it can offer.

For much identification of materials the microscope is simply not essential provided careful attention is paid to macroscopic examination. The latter can sometimes be assisted by the use of a glass, preferably on a stand, with x 2 or at most x 4 magnification. This does not distort the appearance of surface grain in the way that a microscope can, but still offers assistance to the naked eye. It has the advantage of movement in all planes so that awkward angles of an object may be examined. Too often it is not possible to focus a standard microscope on the portion of an object most suitable for identification purposes. It should be noted that most of the microphotographs of ivory and related materials published by Penniman are taken at x 4 magnification.[26]

Another difficulty with the microscope is access to the equipment. This need not be elaborate for simple identification: a basic school binocular microscope relying on natural light can be effective. Magnification at x 15 is generally satisfactory. However, a more sophisticated microscope, with attachments for camera, is essential for microphotography and to ensure a permanent record for use as evidence of identification.[27] Such equipment is not always available in museums or <u>apothekes</u>.

Finally there is the problem of recognising the criteria for identification under the microscope. There are few examples of microphotographs of ivory or bone for comparison. Those taken by Penniman at x 4 magnification are perhaps the most useful, but it should be remembered that these are of sections of the raw material. Beccari, in Studi Etruschi III, provides a number of interesting photographs of ivory at x 55 magnification with several views of worked bone for comparison.[28] Here the basic structural differences between bone and ivory become clear. While at lower magnifications bone will merely appear more 'grainy' than ivory, in Beccari's tav. XLII 1-4 the actual cellular structure of bone is evident. Ivory, a non-cellular dentine, appears under magnification as a homogeneous substance composed of fine, roughly parallel lines. These may be wavy as in Beccari's illustrations on tav. XLIII (especially 1 and 3).

Since the features of ivory are more easily recognisable than bone and appear at lower magnifications, as Penniman's photographs show, they are probably the most simple criteria to test under microscopic examination. As in macroscopic examinations there is here the difficulty that not all surfaces of an object will offer a suitable area to view under the microscope. Intricately carved patterns or surfaces with heavy manufacture marks are quite useless as they confuse the appearance of the physical structure at all but very high magnifications. Broken edges, especially new breaks which are free from grit or encrustation are most helpful. It is often necessary to determine the way a piece might have been cut from a tusk, if ivory. This will allow an assessment of the most likely portion of the object to yield information about the physical structure. Once again the Royal Road inlay plaques may be used as examples. Their upper surfaces appear, to the naked eye, as either wholly homogeneous or with slight traces of 'cloud and ripple' pattern. These features are also visible at x 15 magnifications. The underside of the plaques with rough scoring is useless for either macroscopic or microscopic identification of material. It is the ends of the plaques, where not impeded by tongue and groove arrangement, that offers the most conclusive proof of material used. In many cases the laminations are only just visible to the naked eye; while in others they will appear only under magnifications of x 15. But the angle is not an easy one to manipulate under a conventional microscope. The square inlays present even greater problems since all the lateral edges bear fine saw marks, the undersides are scored and the upper surfaces are completely homogeneous (pl. 39b) with no evidence of laminations either to the naked eye or under magnification. It is that homogeneity which suggests ivory rather than bone; but the use of only a simple microscope has added little to the information derived from other tests.

Pins are another category of objects which can frequently be confused as to their material and may be profitably subjected to microscopic examination should other tests fail. When ivory is used for making pins, and this is rather less frequent than might be imagined, the material is cut roughly lengthwise along the axis of the tusk. This is clear in the Minoan hooked pins illustrated in fig. 73 and pl. 75. In the case of the fragments, splitting has already occurred along the laminations thus confirming identification as ivory. In the larger example (pl. 75a), the thin parallel lines of dentine were obvious under magnification, corresponding to the line of breakage near the top of the hook. Of course the material of this piece was never in serious doubt owing to its size and shape. Hooked pin shown on Plate 75b is made from bone. Under x 15 magnification, the striations of bone, that is the nutrient foramina, appear as short black lines, roughly parallel to the axis of the shaft. This is, in fact, a feature of all bone pins which must be cut from a longitudinal splinter of long bone. However highly polished a bone pin may be, these striations of bone should appear, if not to the naked eye, then certainly under magnification.

Finally there is the problem of re-identifying the material used for Cretan seals by means of microscopic examination. In some ways this class of objects is the most deserving of closer and more accurate identification in view of the early date of ivory in Cretan contexts and its implications for trade. The seals do not, unfortunately, readily lend themselves to microscopic work. Since they are often carved in the round, they can be most difficult to manipulate under the microscope. Their flat surface too often is that selected for the seal face and hence is of little use for observation. Manufacture marks are equally distracting. Others may be burnt with the ensuing changes in physical structure discussed above; or they may be calcified, causing confusion with white steatite. As in the case of plaques and pins it is first necessary to decide from what angle the seal might have been cut, if ivory. This should assist recognition of the physical structure when viewed under the microscope.

The photographs and drawings in Figure 16 and Plate 36a of an ivory segment in my own collection will further illustrate the problems. A transverse cut through the tusk (16c) will yield a pattern of concentric lines near the centre of the tusk and intersecting lines (the lines of Owen) toward the outer edge. A tangential cut (fig. 16b) will produce roughly parallel wavy lines (cf. Beccari XLII,6) near the circumference and straighter lines toward the centre of the tusk. A longitudinal cutting will yield long parallel lines down the longitudinal axis of the cut with a more wavy pattern evident toward the outer edge (fig. 16d). Since a seal is likely to cross any number of these planes there is likely to be some confusion in determining the material, particularly if there is a limited choice of suitable surfaces for examination.

Seal HM 2012 may be used to illustrate the benefits of the judicious use of a microscope in conjunction with other tests. Like others from Lebena it was published as 'Bein' in CMS and recorded as ivory in the Iraklion Museum inventory. From its shape, there are no immediate clues as to material used; and its size (L.0.02 m, H. 0.01 m) does not preclude the use of bone. From a macroscopic examination of its surface features there were no positive signs that the material was bone or ivory (see pl. 39c, fig. 17). The smooth upper portion of the barrel seemed relatively homogeneous without clear signs of either lamellae or striations. The cracking at the ends was not particularly consistent with ivory, yet not impossible. In one area, the upper surface of the seal had been broken and mended. It was an old break and rather dirty, without definite clues as to the material.[29]

On the upper left hand side there was some irregular splitting (see fig. 17). This splitting was the most definite indication that the piece might be ivory, although bone may split in regular, even concentric patterns, particularly when a portion of the shaft of a long bone is used, as would be necessary were this piece made from bone. However, under the microscope the lines of splitting were matched by fine parallel lines, slightly wavy. They were not entirely regular as one might expect of laminations, nor did they appear to 'travel' at great length. Nonetheless, they could not easily be compared to the striations of bone. Instead, under the microscope at x 15 magnification it was clear that they were laminations distorted in similar fashion to those on burnt seals such as HM 1928 and 1936 mentioned above, where the material was in no doubt. Further investigation showed how the seal could have been cut from the tusk (fig. 17) producing a pattern of wavy lines and breaks on one end which would have been slightly distorted under the high temperatures and resulting in the present condition of the seal.

The above example shows that only an integrated approach to the identification of materials will be successful. That is, resort to the microscope alone cannot always show which material was used for a given object. Moreover, the microscope, at least a simple one, is unlikely to distinguish between types of ivory. Thus boar's tusk which is composed of dentine structurally similar to that of elephant ivory, will appear similar to true ivory in small pieces under the microscope. It is true that the patterns in which the dentine of boar's tusk are laid down differ from elephant ivory, as Penniman's photographs show.[30] However, since the planes of a tusk from which a small ivory object such as a seal may be cut are great and the area for identification is often small, the likelihood of positively identifying boar's tusk on microscopic grounds alone is slight. More reliable will be the morphological criteria or presence of enamel as discussed above. The differentiation between elephant and hippopotamus ivory in worked state is still in its rudimentary stages. Some of the possibilities have already been mentioned in the previous chapter (above p. 75). Here it is only necessary to reiterate the point that while the patterns of dentine between the two ivories differ, in small worked objects these are unlikely to be definitive proof. Work at higher magnifications where the actual tubules of dentine may be observed may be useful for distinguishing hippopotamus from elephant ivory. A similar procedure, with emphasis on isolating the individual cells of bone, might also be pursued to secure identification in that small number of cases where lower magnifications cannot suffice to differentiate between bone and ivory.

Chemical tests

As a postscript to the problems of distinguishing bone from ivory, a word may be said about the possible application of chemical tests. To my knowledge no test has been developed to differentiate between these two materials although chemical tests for the authenticity of ancient ivories have been used [31], while methods for determining the sources of modern ivory are in their experimental stages.[32] Unfortunately, all such chemical tests on these materials are destructive.

CHAPTER IV

MANUFACTURE METHODS

INTRODUCTION

This chapter will attempt to evaluate the nature of our evidence for methods of working bone, ivory and related materials during the Aegean bronze age. Evidence may be derived from the objects themselves such as roughouts or waste pieces, together with manufacture marks on finished objects from Aegean sites. Tools and workshops may also suggest aspects of bone or ivory working and consequently the difficulties of distinguishing tools used and of isolating workshops will be considered. A second category of evidence which may be broadly termed comparative data includes information derived from the raw materials themselves and also encompasses scientific and technical studies of bone working undertaken by colleagues in other spheres of archaeology. Experimental methods for producing copies of bone objects and ethnographic parallels may likewise be included in this category of evidence. These aspects will be presented in the last section of the chapter. The preparation of materials, because it is so basic to our understanding of the Aegean evidence, will be considered first, even though it more properly belongs in the area of comparative evidence.

PREPARATION OF MATERIALS

An understanding of the nature and properties of bone and related materials is essential to any study of manufacture methods. As shown in chapter II above, it may give direct evidence for selection of particular materials for certain objects based on the natural characteristics and potentialities of the material. Moreover a study of the principal types of tools and small objects in bone, consistently shows a tendency to select materials which require the minimum degree of modification, that is the least amount of labour, in order to produce the finished product. Such observations can only be obtained by comparing finished products with the raw materials. An understanding of the materials is also crucial in providing clues to stages in manufacture rarely preserved in the archaeological record. Thus, one may deduce the steps probably required before bone can be worked, or the use of certain items in ivory carving for which we have no archaeological evidence. Finally, experimental methods can only be applied if the properties of the materials are clearly understood.

Many of the features of the materials have already been presented in previous chapters. Here we may summarise those most relevant to the problems of manufacture methods.

Bone

It is generally agreed that bone, the material, cannot be treated with other substances to facilitate working. Nor can old bone, that is, bone recovered from natural deposition, be profitably employed in the manufacture of tools since much of its organic content would be lost. Fresh bone is, however, covered with flesh, ligament and cartilage and contains marrow. Metapodials, while having little flesh cover, must be extracted from the hoofs. It seems that the ligament becomes increasingly tough as time passes since slaughter (below p. 176). It is possible that some gentle boiling or soaking might have been used to remove the unwanted materials. This stage could not be lengthy since not only the organic constituent, collagen, but also the natural fats, would be lost. Even with soaking, a sharp blade would be required to remove all the ligament.[1] Marrow extraction could be effected by the removal of one epiphysis. One of the chief disadvantages of the use of bone are these preliminary stages, which though not difficult, are nonetheless messy. Unfortunately we lack direct archaeological evidence for these processes and can only infer their practice through a knowledge of the materials, possibly with the support of experimental techniques. Thus, while the existence of pre-working treatments cannot be doubted, we cannot be more specific about their nature in the Aegean bronze age, the organisation of these processes in the economy of the site, the length of time they took, whether the same process was repeated for individual tools, or whether there was any industrial organisation of this stage of manufacture.

Antler

Antler may occur in two forms: shed and fresh, and is so known from Aegean sites (above p. 28). Shed antler is said to be harder and, therefore, presumably less desirable for working. Fresh antler, from a slaughtered beast, will of course still be attached to the animal's skull and therefore require removal. The fact that we have several examples of antler attached to the pedicle (pl. 9b right; 9c left) is curious but suggests that it was easier to proceed with the task of cutting the antler once completely separate from the body. In that case the pedicle could be cut or broken away from the skull soon after the kill instead of the laborious task of sawing through the main beam while pedicle and antler were still attached to the carcase.

According to the literature, antler may be soaked in water before working in order to soften it. This may be specially beneficial in the case of shed antler.[2] Other researchers have found that dilute acid solutions were helpful.[3] Moreover, soaked antler can even be bent.[4] Here the evidence from the properties of antler is much less clear cut than from bone, since there is no indication that antler cannot be worked without pre-treatment, merely that such treatment may facilitate working. Without specific archaeological information we cannot determine whether this approach was ever adopted by workers of antler in the Aegean bronze age.

The seasonal nature of antler availability raises a further question regarding manufacture. Since a number of tools could be made from a single antler, it is interesting to speculate whether all would be manufactured at the time of acquisition, or whether the antler was stored until further implements of that material were required.

Ivory

As with bone and antler, several preliminary steps in ivory working may be inferred from a knowledge of the material, although specific evidence is lacking from Aegean archaeological contexts. The principal difficulty facing the carver is handling the tusk itself. Before carving of individual items can begin, the tusk must be cut into manageable sized segments. For this a grip or rudimentary vice of some sort would be almost essential. Furthermore a padding of soft material, perhaps straw and cloth would be needed to prevent the tusk from moving and serve to cushion harsh blows. Decisions regarding the most efficient sectioning of the tusk to prevent waste of the precious material would also be necessary. The specific difficulties of the enamel, root cavity and black lines at the tip of the tusk have been enumerated above (p. 40). Although ivory will not respond to soaking, as claimed for antler, likewise it does not require the removal of organic materials as in the case of bone.

General

All the materials considered in this study are relatively soft: bone and ivory both register about 2 on the Mohs scale with only the enamel of elephant and hippopotamus tusk being significantly harder. This allows us to deduce that a relatively simple tool kit would be required for working the materials. Obsidian blades with addition of suitable abrasive substances would be adequate, although the use of bronze tools especially for ivory carving is fairly certain by the LBA.

ROUGH-OUTS AND WASTES

Partially finished pieces or rough-outs can sometimes provide useful evidence for manufacturing methods of bone and ivory. Related to these are waste pieces and off-cuts bearing signs of working. They may offer insights into particular stages in working and the presence of tool marks is a potential source of information regarding types of implements used to manufacture objects in bone and ivory. In addition, the presence of rough-outs or wastes on a site may point to the existence of specialised working areas or workshops (below p. 166).

The chief difficulty with the evidence of rough-outs and wastes is initial recovery of such material. It is highly likely that much of this evidence has gone unnoticed in excavation, particularly before more rigorous methods of recovery and the examination of faunal remains by specialists became standard practice. Fragments of bones with tool marks, but preserving no recognisable shape, may easily be missed. Not surprisingly, the number of rough-outs for bone tool or pin manufacture in the Aegean is very small. Waste pieces from such processes are negligible, although it is not always easy to draw a fine distinction between a rough-out and a piece, partially worked, and then discarded as unsuitable. For this purpose, 'waste' will generally refer only to those pieces of bone or ivory of which no further use could be made. In the case of antler working, much of our information comes from the site of Ayia Irini, where large pieces of antler, with heavy tool marks were recovered. The presence of a faunal analyst ensured that these waste pieces were recognised and preserved for study. There are also a few examples of rough-outs or partially finished objects in addition to the waste.

The best group of rough-outs and waste pieces occurs for ivory. This may be partly due to the concentration of ivory working in palace workshops and the fortunate discovery of such areas. Ivory, both partly finished or 'unworked' has also been recorded on non-palatial sites including Ayia Irini, Palaikastro, Phylakopi and Nichoria on the mainland.[5] Here it is clear that the precious nature of ivory ensures its preservation and publication in a way that a fragment of unworked bone would not.

Stages in working: Bone

Evidence for different stages in bone tool manufacture is lamentably slight for the Aegean bronze age. From the one thousand pieces of worked bone and antler from Lerna, only a handful of partially worked pieces exists. In bone there are but three examples, none of them positively related to bone tool manufacture. It is possible that rough-outs were not isolated from the faunal remains, although it should be remembered that the animal bones were studied by Gejvall.

The first piece from Lerna is clearly in a very early stage of working (pl. 5b, right). It is a whole deer metacarpal with deep groove just above the distal epiphysis (71: 6). There are also slight indications that some working was made along the natural medial groove of the bone. The incision at the distal epiphysis could be connected with the removal of marrow (above p. 117) but it is more likely to be related to a specific type of manufacture. We must therefore attempt to deduce from this piece what the succeeding stages of manufacture would have been, and what finished piece could have been intended.

As discussed above (p.16f) cattle or deer metapodials are rarely made into implements preserving the entire epiphysis as a grip (Type 1) owing to the size of the articulation and of the bone itself. One of the few exceptions to this statement is illustrated on Plate 53c (1a: 25, fig. 32). Furthermore, where metapodials (usually sheep/goat) are used for Type 1 tools, it is the distal epiphysis which is retained as the grip. The bone and the removal of that epiphysis in this example from Lerna suggest that a Type 1 tool was not intended. A final argument against such an end-product is the regular groove at the distal epiphysis, an unnecessarily laborious approach to manufacturing a Type 1 implement (also below p. 145).

Cattle and deer metapodials are, however, most commonly used either to make Type 4a pointed implements, preserving approximately $\frac{1}{3}$ to $\frac{1}{2}$ of the proximal epiphysis as grip (pl. 59, figs. 39-41); as splinters for smaller pointed implements (Type 5a, pl. 61); or to provide thick sections of compact bone for pin manufacture. It is difficult to ascertain from this piece, as preserved, which of these end-products was the most likely. The fact that there has been some enlarging of the natural groove down the medial anterior facet of the bone tends to argue against the production of a Type 4a tool as most examples of that type are made by cutting the bone lengthwise through the anterior/posterior plane (see fig. 18a). Preliminary incision along the medial groove on the anterior facet and along the corresponding groove on the posterior would, however, be consistent with obtaining segments of bone for pin manufacture or small pointed implements. After dividing the bone longitudinally along the median (fig. 18b centre) smaller segments, wedge-shaped at the proximal end, could be cut as desired. The rough-out or waste (71: 2) on Plate 5a from Ayia Irini discussed below, may represent a later stage in this process.

Two final pieces of information may be elicited from this piece. First, while it is possible that the bone was destined for tool manufacture, circumstantial evidence suggests that pin manufacture may be more likely. Deer metapodials are particularly suited to this because, in addition to the thick-walled shafts they have in common with cow metapodials, they provide a much greater length of straight shaft, especially beneficial in the production of long fine pins, for which Lerna is noted. Secondly, the pattern of incision suggests that the general method of sectioning the bone conforms to the traditional groove and splinter technique which prevailed in most prehistoric bone working. Grooves, cut in at an angle, are made on the bone where the segment is to be removed. After working with a blade and possibly abrasive to a certain thickness a piece of wood may be inserted to apply pressure for splintering out the required segment of bone. As expected, on the Lerna metapodial the incisions are deeper on the lateral edges of the bone where the amount of compact bone is thicker.[6]

A portion of a deer metatarsal (71: 7) illustrates how poor our recovery of rough-outs is from Lerna. About ⅔ of the circumference of the shaft remains; one end is cut across quite straight, the wide is broken irregularly (pl. 5b, left).[7] There are horizontal incisions near the ends. It seems that the segment of the shaft may have been removed by groove and splinter technique.[8] This piece could, therefore, represent an intermediate stage of sectioning a whole long bone into smaller pieces for tools. Nonetheless, in spite of definite signs of working, its association with a specific stage in tool or pin manufacture remains conjectural.

Finally from Lerna is a segment of a cattle metapodial in an advanced stage of working (fig. 19a, 71: 8), but which relates to no other bone object on the site. The piece preserves the natural concavity of the bone, the sides have been cut relatively straight and the two ends are very slightly convex. The piece presents several problems, not least because it appears rather well-finished. On one end there is a slightly bevelled edge where the piece was apparently broken and then rubbed down. Its nearest parallel is a bone object, perhapsaplaque, with bevelled edges from Ayia Irini (fig. 19b). The resemblance is not very close nor do plaques occur at Lerna.

On the whole, Ayia Irini provides better evidence for stages of bone working than does Lerna, although the number of pieces does not exceed one dozen. Again, not all of these can categorically be classed as stages in manufacture: some may be mistakes or wastes. The three best examples are illustrated in Plate 5a and fig.29 . 71: 1 (pl. 5a right) is a rather flat splinter of a cattle metapodial, preserving only a little of the natural concavity of the shaft. The lateral edges show signs of working but they are not wholly regular. This piece appears to have been removed from the bone by groove and splinter technique but given very little additional working. Although from a different type of bone, this piece may be compared with 71: 7, the stag metatarsal fragment from Lerna as perhaps being complimentary views of the same stage in manufacture. Whether 71: 1 was to be further worked cannot of course, be ascertained. Its shape would allow the production of a fairly thin inlay plaque or implements of Types 5 and 18.

A further stage in manufacture may be represented by 71: 2 (pl. 5a left), a heavily worked segment of cattle metapodial, representing at most ¼ the circumference of the shaft. Traces of cancellous material remain at each end indicating that the entire length of the bone has been extracted. The two oblique facets have very regular tool marks, the surfaces are smooth and evenly cut. That is, after the segment had been removed from the bone, presumably by groove and splinter method, additional working of the lateral edges has taken place. The amount of compact bone preserved in the wedge-shaped section, together with the length of the segment (0.17 m) suggests that this piece was connected with pin manufacture.

That may also be the case with 71: 3 (pl. 5a centre), a heavily worked segment of cattle metapodial. The two lateral edges have been carefully cut to form oblique facets and taper sharply to a point. The proximal end has also been evenly cut. There is certainly sufficient compact bone at this proximal end for shaping into a pin head, while the length of the piece, nearly 9 cms. does not preclude a pin as the finished product. Were a small splinter tool (Type 5) intended, it is unlikely that the oblique facets would have been so carefully cut, and that the taper would have been so sharp.

Three rather roughly worked portions of sheep long bones might represent stages in the manufacture of bone implements. 37a: 5 (pl. 40a, left) is the proximal end of a sheep metatarsal. Three facets with irregular, horizontal tool marks run down the shaft. The lower end of the shaft has been roughly cut off. It seems that this piece might have been an early stage in making a bone handle (Type 37), although it is most unusual for objects of that type to have modified shafts (cf. 37a: 10, fig. 105 from Ayia Irini). Another piece which might have been intended for use as a handle is 37a: 2 from a distal sheep tibia. Here the lower portion of the shaft has been roughly cut or broken away. Just above this point are five short, parallel incisions, at right angles to the axis, suggesting that the piece was to be cut transversely. There are a few traces of tool marks on the epiphysis also, but this portion has not yet been smoothed for use as grip as is normal for either handles or type 1 implements. Finally there is a worked proximal sheep metatarsal, 71: 4 (pl. 40a,right). Here the shaft has been rather roughly cut or split lengthwise along the main axis. What is curious about this piece is that the posterior face of the bone has been cut rather than the anterior as is normal in making implements of type 1. It accounts for the rather sharp lateral edges preserved on this piece. Although the lower portion of this piece is now missing, the appearance of the upper part of the shaft suggests that this piece was probably never finished.

A late stage in pin or needle manufacture may be represented by 10b: 2 (pl. 40b, fig. 61). The head of this piece flares out asymmetrically and has a transverse notch across the top of the head. Just below the top of the head is a horizontal incised line; below that, a small nick or depression exactly centred on the shaft. These features seem to suggest that a further step in manufacture had yet to be completed: possibly the drilling of an eye or carving of a head. That the piece may not have been completed is likewise suggested by the parallel tool marks running down the length of the shaft. In most finished pins these would be eliminated through polishing.

From the Citadel House, Mycenae come two further examples of the later stages in bone pin manufacture. 71: 10 (fig. 20a) is a long piece of bone heavily worked with a roughly hexagonal section. On one facet, for about half the length of the piece, is a slight depression which seems to be the remains of the marrow cavity presumably of a metapodial. Fine regular tool marks appear at the facets near the tip which is now slightly chipped. The identification of this object with a finished pin cannot be wholly secure. It is possible that the piece might have been intended for use as a stylus, with the hexagonal rather than round section affording better grip, much in the way a modern pencil does. If this is the case, the piece as preserved might have required very little additional work before completion.

By comparison, 71: 11 (fig. 20b) can be securely linked with a known type of Mycenaean pin represented at the Citadel House and elsewhere.[9] It is clearly unfinished but in an advanced stage of manufacture. The somewhat bulbous head has already emerged but the shaft below is rather square in section and remains square through the taper toward the tip. Fine tool marks appear on the facets, running roughly diagonal to the main axis of the shaft. The final stages in working would probably have been accomplished by the use of a rubbing stone or other abrasives.

A few other rough-outs or perhaps waste pieces of bone also come from the Citadel House, probably to be associated with plaque or inlay manufacture. There are no sure examples of early stages in bone tool working, although the implement illustrated on Plate 40c (71: 12) is a possible candidate. 71: 15 and 16 (fig. 21d and e) are fairly broad flat pieces of bone, probably cattle, with some traces of the natural concavity preserved; only one end is preserved intact on each, but these have been neatly cut. The wedge-shaped pieces 71: 9, 13 and 14 (fig. 21 a-c) also from long bones, may be waste rather than unfinished pieces.

The above survey does not include every single example of an unfinished piece of worked bone from the Aegean, but represents the majority of pieces and principal types which I have encountered. Some pieces may be waste, others offer no clear suggestion as to the stage of manufacture reached. It is obvious from such a collection that no definitive account of stages in working and manufacture methods as a whole can be derived from the unfinished pieces alone.

Stages in working: ivory

Citadel House, Mycenae

The Citadel House, Mycenae, offers the best collection of partially worked ivories as yet recovered from the Aegean. Whether an ivory workshop existed on the site as excavated is not wholly clear (pp. 52 and 284f) but the presence of unfinished pieces of the material in various locations on the site does suggest the existence of a workshop in the vicinity. The majority of the unfinished ivories were found in a small storeroom-cum-shrine near the Temple.[10]

The pieces fall into two main categories. First there are roughly worked pieces and wedges probably reflecting early stages in manufacture but which give no particular clues to the end-products envisaged. Second, there are a few pieces in rather more advanced stages of working whose shape suggests a possible type of finished object. As with the pieces of partially worked bone discussed above, there is often considerable difficulty in ascertaining what precise stage in manufacture is represented and whether a given piece has been discarded as waste.

One piece representing a very early stage in manufacturing is the tusk tip (74: 34; fig. 11a; pl. 41a) already described above (p. 40). The piece has merely been sawn off the remainder of the tusk and only a little additional modification to the external surfaces can be detected. It is quite possible that at this stage no particular end-product was planned for the tip but that it was being reserved for future working.

Other examples of early stages in working include a group of roughly worked segments with curving edge derived from the natural shape of the tusk. The wedge 74: 19 (pl. 41b, fig. 22a) actually preserves some of the external surface of the tusk. The other three edges of this piece are cut fairly straight with one near right angle. Figure 22b illustrates how this piece may have been removed from the tusk. It is unlikely that the piece as preserved is the result of a primary cutting of the tusk. This seems to be confirmed by the heavy, but fairly regular diagonal tool marks on the upper and lower surfaces. The shape is curious, and is not easily recognisable as a rough-out for any particular finished object. It might, on the other hand, be a large off-cut from another process, now being prepared for manufacture of smaller objects. It is certainly large enough to produce a variety of small pieces such as inlays, but much additional work would be required to reach a shape suitable for their manufacture.

Another wedge with curving outer edge is 74: 32 (pl. 42a). This piece is a fairly thin, flat segment of ivory, with the upper and lower surfaces quite evenly cut. The inner edge is very rough and suggests prising away from the main block of ivory rather than careful sawing. This too may be an off-cut from another process, but the fairly carefully worked upper and lower section would then indicate that secondary manufacture, probably of a small inlay, had already started. This could likewise be the case with 74: 20 (pl. 42b, fig. 11c) which has deep incisions remaining from an earlier process but also signs that further use would be made of this segment. Finally 74: 18 (pl. 42c) may be included in this group, although its size and shape do not really support the possibility of further manufacture. The curving outer edge may preserve some of the original surface of the tusk but also bears several deep incisions and other tool marks. Other surfaces are similarly covered by heavy tool marks; the edges are roughly cut. Whether any small piece could have been made from this wedge is difficult to determine. It might have provided ivory for joins or pegs. Whether it had been saved for such purpose would depend on the availability of ivory and value of conserving small pieces. (Cf. modern segment of similar shape pl. 36b,c).[11]

A larger wedge-shaped segment of ivory which was likely to be further worked is 74: 25 (pl. 18c). In spite of its poor state of preservation it is clear that this piece has been quite carefully cut on most edges, particularly the triangular section. Only the upper edge is rather crudely sawn. Toward the narrow end on the underside are some irregular tool marks. Elsewhere they cut diagonally across the piece in regular fashion similar to those on 74: 19. It seems likely that 74: 25 is also a second or third stage in sectioning the tusk, but preceding the point where a rough-out of an actual object can be detected. Both these pieces present difficulties of interpretation. What finished piece could be produced from wedges of these shapes? That is, can any pieces in the Mycenaean repertoire be related to wedge-shaped blanks? None come readily to mind. Flat rectangles for relief carving and inlays or cubes for three-dimensional carvings are the expected shapes. A slightly tapering section can be helpful in comb production (below p. 133) but 74: 25 with its thick curving edge does not seem a likely candidate. Some objects do have a curving edge when finished such as 70: 29 of unknown purpose shows (fig. 11b), but here the section is flat and not tapering.

The block of ivory 74: 24 (pl. 17a-c) is yet another example of an early stage in manufacture. Here we have a slightly irregular cube with heavy signs of working on all surfaces. All sides have been evenly cut. This may indicate that a series of flat rectangular sectionsof ivory similar to 74: 28 (pl. 44b, c and below p. 133) have been removed for manufacture into other objects. This was the interpretation presented by the excavator Lord William Taylour in preliminary reports on the material.[12] If this is correct, the remaining block could easily yield several additional blanks for plaques, or in turn be used for an object in the round such as a large pommel, furniture decoration or sculpture. Alternatively the block could have been cut intentionally into its present shape.

The next group of unfinished pieces from Citadel House has reached a further stage in manufacture, with more distinct shapes emerging. There are two triangular segments, 74: 33 and 26 (fig. 23a, b and pl. 43a) which have been much worked. Both shape and size indicate that they are several stages removed from the whole tusk. Furthermore, while clearly worked on all faces, the tool marks are extremely regular and rather light. That is, the heavy tool marks visible on pieces discussed above have been obliterated by further working. The fine diagonal marks on one end of 74: 33 are quite consistent with those to be seen on unexposed faces of finished objects. The light tool marks on the oblique faces could be removed without difficulty by the use of abrasives. Unfortunately no particular finished object from Citadel House conforms to the trihedral shape offered by these pieces. Small inlays or attachments seem the most likely end-products.

Three partially finished plaques also represent fairly advanced stages of workmanship. 74: 23 (pl. 43b, c and fig. 24a) has one long edge very carefully cut and one near right angle. The piece is not quite flat, tapering somewhat to the roughly cut long edge. Several deep incisions appear at one end and the underside has relatively heavy tool marks. It would appear that the piece was in the process of being smoothed and flattened and having its edges trimmed. This may also be the correct interpretation for 74: 22 (pl. 44a, fig. 24b), a thin plaque with one reasonably straight long edge and two near right angles. The other long edge is not however quite parallel to the first and has rather odd triangular notches on the edge. Unlike the other edges, this is not cut perpendicular to the surface but at a slight angle. There are fifteen notches in all, spaced irregularly. I have encountered no parallels for such notches on ivories and can only surmise that they may have some connection with the final assembling or attachment of this piece. The underside is covered with many tool marks, but the heavy criss-crossing is similar to that found on the backs of other inlay plaques and may well represent deliberate scoring to provide a key for adhesive rather than traces of manufacture marks which had not been removed.

A very late stage in manufacture seems to be represented by 74: 28 (colour plate X; pl. 44b, c; fig. 25) a flat rectangular plaque, almost square in plan with near right angles at all corners. In section, it tapers from one centimetre thick at the top edge to only two millimetres at the bottom. The piece is now heavily coated with PVA giving the impression of a highly polished surface. The interest of this piece lies in two areas. First, in shape it appears to be the most advanced of the unfinished pieces of ivory from the Citadel House. All sides but the bottom edge have been carefully cut square. Moreover, the tapering section and dimensions give clues to its possible finished shape. Rather than a low relief plaque which would demand uniform thickness, this piece could well have been a blank for a comb. Teeth are generally somewhat thinner than the handle portion, which may be carved and the teeth themselves taper toward their tips. Of course it is impossible to prove conclusively what a piece at this stage of manufacture would have become, but this is the only example from the Citadel House where the existing shape might approach that of a recognisable end-product.[13]

The second interesting feature of this piece is the nature of the tool marks. They are quite unlike those on other partly finished pieces from the site. On the upper surface (pl. 44b) they occur over roughly the bottom half of the piece only and run right to the lower edge. Those on the underside cover most of that surface and are not quite so regular (pl. 44c). The marks are not the heavy rough type seen on such pieces as the wedge 74: 19 discussed above; nor the fine regular knife marks perhaps indicative of a later stage in manufacture as on the triangular pieces 74: 26 and 33. Instead they seem to have been made by an implement with fine, rather regularly spaced teeth. A drawing of the marks at x 15 magnification may be seen on Figure 25. The dark area indicates the lower level. Each set of marks seems to run for about one to two centimetres in length. It is difficult to gauge the width of the implement but the marks seem to occur in sets a little over one centimetre wide, although there is clear overlapping and slight changes of direction occur. The sets consist of several grooves about one or two millimetres wide. The marks are best seen on colour plate X. The general direction of work seems to have been bottom to top and the marks appear to have been caused by pushing the tool forwards in the manner of a chisel since the marks are deeper at one end of the 'run' than at the other.

We must now try to decide at what stage the work was halted. Was the entire surface to be cut away by this tool, and work stopped before the upper half was finished? Or were those tool marks the remains of an earlier process, not yet obliterated by the final stages of manufacture and polishing? The second interpretation is probably the more likely since the upper half of the piece has no signs of any tool marks, on the upper surface at least, which one could associated with early stages in working. On the contrary the surface is quite smooth. Presumably toothed tool marks once covered that portion but were subsequently removed by means of abrasives. If a comb was indeed the intended end-product then the lower portion need only have been treated with abrasives after the teeth had been cut.

It will of course be recognised that some of these interpretations of stages in manufacture are highly conjectural. The intentions of artists and craftsmen can rarely be determined with certainty. Some experimental work in sectioning whole tusks might give additional information for comparison with the possible stages represented in the Citadel House collection. However, it would still not tell us what the ivory segments were destined for, only, with luck, how they might have been removed from the tusk.

Other unfinished pieces from Mycenae

From elsewhere at Mycenae examples of partially worked ivory have been recovered, in some cases in stages of manufacture sufficiently advanced as to indicate their final form. These include the plaque ANM 2459 (see Type 62) from Tomb 27 and the statuette ANM 2578 (64a: 8) said to be from a tomb on the Acropolis. Although it seems quite clear what their final form should be, why these pieces were left unfinished is puzzling. The statuette, well illustrated by Sakellarakis, was in his view possibly broken during the final stages of manufacture, thus accounting for its unfinished state.[14] With the relief plaque ANM 2459 there is no obvious clue as to why carving was halted. Since both pieces were not in workshop contexts, as might be expected, but in graves, it may be that even unfinished or damaged ivory pieces were considered valuable.[15]

A potentially rich source of information regarding stages in working ivory may be available in the future from the House of the

Shields and House of the Sphinxes. Until Sakellarakis' recent study there was little indication in the literature that the ivory objects from these sites outside the citadel were anything other than finished ivories, chiefly small inlay plaques of characteristic Mycenaean type: rosettes, lilies, columns and the like.[16] It now appears, thanks to Sakellarakis' study of the finds in the Athens National Museum that both these houses may have been involved in ivory production (further below p. 171). He reports and illustrates a few examples of ivories in various stages of production, including blanks for small plaques and inlays; inlays with rudimentary lines of incision for engraved decoration; and from the House of the Sphinxes, columns with hexagonal shafts awaiting the final stages of rounding off and polishing.[17] There is no mention of larger blocks of ivory from which these smaller plaques were cut, but some small pieces of waste ivory seem to have been recovered (see 74: 13). Sakellarakis' summary of the types of unfinished pieces from these two houses is, therefore, tantalising. Much more detailed information regarding specific stages in manufacture and working techniques will undoubtedly be gained from a close examination of this material.

The ivory deposit, Knossos

Although chronologically earlier, the material from the ivory deposit on the Royal Road, Knossos has been relegated to second place in this discussion since the specific links with stages in manufacture of ivory objects are not so clearly evident as in the case of the Mycenaean material. Nonetheless this deposit does provide us with valuable evidence for certain aspects of ivory working not available from Citadel House. From the Royal Road deposit there are no large, partially finished blocks or rough-outs. Apart from a large collection of small finished items, mainly plano-convex plaques, squares and inlay strips, most ivory recovered may be termed waste. This is not by any means a uniform category and several groups may be isolated. First there is the true scrap ivory, very small off-cuts of which no further use could be made. Roughly two kilograms of these small fragments, measuring only a few centimetres across, were recovered. Many bear tool marks on all surfaces (pl. 20a). Next there are larger fragments of ivory, often heavily worked, which seem to be waste in that they fall into no consistent pattern of shapes. Occasionally one might appear as a possible rough-out. Some of these pieces might also be re-worked to produce some very small finished object as suggested for some of the Mycenae segments. Other pieces, more or less conforming to the same shape, wedges with one concave edge which are clearly wastes from a specific process. Finally, there are the peg wedges some of which may be clearly linked to an end-product also present on the site.

The scrap ivory (74: 4) can tell us little about the actual stages in manufacture of specific objects. Most pieces seem to be the result of paring down larger rough-outs and may be compared to the off-cuts obtained from whittling wood. In a few cases (74: 3) it is possible to see traces of enamel or the outer surface of the tusk remaining on the chips (pl. 20b and p. 40) but generally the pieces are too small to give any clue as to what part of the tusk they have come from. The small size of the chips tends to suggest that they are the remains from a rather advanced stage of working when the objects were taking recognisable shape, but preceding the final stages of production. These chips from the Royal Road seem comparable to those illustrated from the 'artisans' workshop' at Mycenae and perhaps those illustrated by Sakellarakis from the House of the Shields although it is difficult to tell from photographs alone.[18]

Some of the larger fragments of indeterminate shape from the Royal Road could have been further modified such as those illustrated on Plate 45 (74: 5). As they stand, they might be indicative of a less advanced stage of working than the small chips and are probably wastes from the initial stages of cutting the tusk into requisite shapes for manufacture. This interpretation may fit another waste fragment (pl. 46a and b). It is an outer portion of the tusk which has been roughly splintered away (pl. 46b showing the underside) while the top and bottom have been cut through. Is this a piece discarded after the ivory beneath it was reached or would it have been used to manufacture small objects such as the square inlays? The fairly neat cuts, top and bottom, suggest that even if waste, this piece may have been destined for additional working. Several roughly circular pieces also fall into this fuzzy category of rough-out or waste (pl. 46c, 74: 6). There are few objects on the site which readily suggest a waste of that shape, although they could be remains of the centre of a ring, roughly cut out and then the interior smoothed down later. The end result might look something like Plate 47a, left. Alternatively they could, perhaps, be blanks for a circular button or inlay of the type seen on the right of Plate 47a.

Perhaps the most intriguing group of pieces from the deposit are the small wedges of ivory with one end curved (pl. 47b and c, 74: 7). They all seem to be wastes from the manufacture of similar objects and yet there are no finished pieces from the site which are characterised by a convex curving edge. A few of these waste wedges seem to have been used in a further process, the cutting of small ivory pegs as those shown on Plate 47c (right).

Of the Royal Road waste, the 'peg wedges' mentioned above (p. 41) seem to give the clearest indication of a stage in manufacture (see pls. 21a, 48). These are almost certainly off-cuts from other processes, as their irregular shape suggests, which have been further used to manufacture smaller objects. Ivory pegs were used extensively on the site in the small square inlays, some plano-convex plaques and number of inlay strips. A few have been preserved intact and in position as shown on Plate 21b, c while others are loose. They seem to have been about one centimetre long and approximately two millimetres in diameter at the head. Plate 48a-c (74: 8, 9) show the pieces of scrap ivory which can be most securely linked to the manufacture of such pegs. Both Evely and I feel that these were almost certainly removed from the segment of ivory by means of a tubular drill. Not all the 'peg wedges', however, can be definitely associated with this process in spite of their superficial similarity. The large example on Plate 48c (above) is far too thin to have produced pegs as it now exists. Yet this cannot be a case of splitting through the laminations, since their pattern is clearly different. Was this piece perhaps further modified after a series of pegs had been removed? [19]

Unfortunately there are no other segments of partially worked ivory from the Royal Road which can be linked to specific finished objects on the site. There are no pieces which seem certain to have been made into squares or strips or plano-convex inlays. Furthermore, all of these appear to have been completely finished, including heavy scoring on the back to assist attachment and with finely polished upper surfaces.[20] There is even a little evidence to suggest some pieces might have been assembled at the time of destruction (further p. 154). Thus the Royal Road deposit presents us with a curious and incomplete picture of stages in manufacture: no large blocks for the manufacture of additional items, no blanks or rough-outs, much workers' debris and many finely finished items. It is hoped that the full publication of the site may provide further information which will help to elucidate the questions of stages and techniques of manufacture presented by the ivory finds.

Ayia Irini, Kea

Before leaving the subject of ivory, it is worth mentioning a partially finished ivory plaque from Ayia Irini (74: 1, pl. 49a). It has been cut into nearly rectangular shape with the edge of the shorter sides slightly bevelled. The other edges are cut square, although one has the remains of a protuberance which had not yet been removed. On the upper surface are long, fairly regular tool marks. In itself, the piece seems to indicate a reasonably late stage in the manufacture of a plaque, although whether this was to be square or another shape cannot be determined. Further work would be needed in straightening the edges and polishing the surface. More significant is the fact that this piece probably indicates that ivory working, on a small scale at least, was taking place at Ayia Irini. We cannot determine, of course, whether tusks were imported whole, or whether the ivory arrived in smaller blocks (above p. 49). This piece does seem to indicate that even if only the latter were true, then the very latest stages of ivory manufacture did occur on the site.

Stages in working: antler

Much of our evidence for antler working in the Aegean comes from Ayia Irini, Kea, where roughly one-quarter of all items in bone and related materials are of antler. The majority of antler pieces are not finished objects but rough-outs or waste segments. As mentioned above, the antler waste provides useful evidence that shed as well as fresh antler was being utilised. Most of the waste falls into distinct groups which seem to reflect stages in the manufacture process, or rather more accurately the wastes remaining from particular stages in the process.

First there are a number of large chunks of irregular shape preserving natural features such as the pedicle or corona. One or more edges will reveal signs of heavy regular saw marks indicating the removal of main beam or brow tine. Some of these are almost certainly true waste pieces (pl. 9c, left; 10b, right; 50a). They would appear to be left overs from an early stage in cutting up the antler into workable segments. That some of these portions of main beam were further modified for use may be suggested by 36:3 (pl. 9b, left) with two straight cut edges and a central hole, now broken. The brow tine is also lost but the piece might have been a close parallel to so-called 'horn club handles' from Thessaly. The similarities are striking even if the purpose is not clear. 72: 22 (pl. 9c, right) from Lerna might also be such a piece.

Another group of waste segments are low cylinders cut from antler main beam or tines (pl. 49b). Most are now hollow, through the loss of their spongy centres; in one or two cases, hollowing out may have been deliberate. Most show clear signs of saw marks, but rarely on the outer surface of the antler. It is hard to envisage these pieces as anything but waste, probably the result of trimming down a tine or section of beam to the length required for a particular end-product.

Several pieces of antler waste from Kea and perhaps one from Lerna give rather better clues to stages in manufacture and possibly even the finished product. These waste fragments are all characterised by longitudinal cuts through either the main beam (pl. 10a, right) or the tine (pl. 50b, right). There can be little use for the remaining segments as preserved. The pieces themselves are the results of the preliminary sectioning of the antler. In Plate 10a, right the main beam has been cut through transversely at the corona and again some eight centimetres higher. On this a longitudinal cutting has been made which would have produced a broad flat segment suitable for final shaping into a celt-shaped implement such as Type 24 or heavily trimmed into a pointed implement Type 13 (pls.12b and a). Plate 50b (right) shows a similar stage, although here a flat segment has been removed by a secondary cutting lengthwise down the tine. The piece remaining is also surely a true waste with few possibilities for further use, while the segment removed would probably have been fashioned into a pointed implement of Type 13. Plate 50c from Lerna presents a less clear cut picture. Here a longitudinal cutting of the tine could mean that this is a waste segment and that the flat piece of tine removed was intended for manufacture into a pointed implement. However, were that the case, it seems odd that such a substantial portion of the beam was retained after the preliminary sectioning of the antler. It may well be that this segment is an advanced stage in manufacturing a chisel or pick-like implement with the beam retained as a handle. In that case, further modification to the cut end of the tine could be expected, producing either a pointed or bevelled working edge (e.g. 23: 2, pl. 11b).

By far the largest group of unfinished or waste antler pieces are tines. In many cases there are few signs of working apart from the principal sawing through of the tine to remove it from the beam. Occasionally, where the piece has been damaged at the proximal end it is not even clear whether these tines were removed by deliberate human action (pl. 51a). Nor is the fact that some of these tines are rather smooth toward the distal end or tip any guarantee of modification or even use, as some smoothing can be the result of the animals' rubbing away the velvet once growth had ceased (above p. 26). Of course, tines could be used with minimal or no modification, but more rigorous examination, especially with aid of a microscope, of the pattern of polish may be required before we can obtain conclusive proof of modification and use.

Other examples of tines were slightly modified and used at their distal ends, although betraying few signs of preliminary stages of work. This may be seen on examples from Lerna (pl. 11b, 22: 9 and 23: 2). Others have been cut neatly across at a certain length and seem to have been rubbed down. Of these some show signs of use at the distal ends and should probably be classed as finished objects (pl. 89). Where there is little sign of modification it is impossible to know whether they were waste pieces or merely awaiting further treatment in the future.

In one or two instances it is possible to guess that the tine was being prepared for manufacture into a handle (pl. 51b, c). In the upper example on Plate 51b, the surface of the tine has been well smoothed although not highly polished and the distal end has been carefully cut across. The lower example (37b: 2) has been worked overall with longitudinal ridges, apparently in advance of smoothing the surface by means of abrasive. Both pieces could, with very little additional modification, have served as handles for bronze awls similar to that from the Citadel House, Mycenae (fig. 9a and pl. 13a). Plate 51c illustrates two similar pieces from Lerna (37b: 4-5).

Since the variety of objects obtainable from antler is more limited than from ivory, the waste antler can provide more precise indications of the stages of working. The nature of finished products may also be suggested by waste segments. Unlike smaller fragments of worked bone, antler waste is less easily overlooked in excavation. Antler does not, however, occur on all Aegean sites and therefore its position in the bone and ivory industries of the Aegean bronze age is equivocal. Whether special manufacture methods, skills or tools were involved in working this material is not clear from the pieces themselves.

FINISHED OBJECTS

As shown above, the evidence from partially finished pieces and wastes can give clues to various stages in the manufacture of objects, although the evidence is neither as extensive nor as clear-cut as we might like. Indeed, with only the rough-outs as a guide we would be hard pressed to reconstruct the bone and ivory industries of the Aegean. It is clear that much of our evidence for manufacture methods must be gleaned from the finished pieces themselves. These can occasionally indicate stages in manufacture, although usually only those most advanced, and may also yield information regarding types of tools used in the manufacture process.

Bone tools

A study of the finished shape of bone tools, together with the manufacture marks still visible on them is a reasonably useful approach to understanding methods and stages of manufacture. Unlike ivory, bone, with its restricted number of shapes when unworked leaves little room for variations in the production of a given finished object. Thus, by comparing an unworked bone and a finished object made from the same sort of bone one may recognise a number of steps which are likely to have occurred in between (although see below p. 176 n.67). Some of the earlier steps must be deduced from the material itself as suggested above, while the later ones may be indicated by tool marks on the surface or finished pieces.

In a Type 1 pointed implement made from a sheep/goat metapodial or tibia one of the chief stages of manufacture is the longitudinal or oblique sectioning of the shaft which will eventually serve as the working end (see fig. 26). On few bone tools from the Aegean is it absolutely clear how this sectioning was effected. It can be produced by a sharp blow from a stone tool on the lower portion of the shaft causing a roughly lengthwise break. Alternatively, the lower part of the shaft could be removed by cutting or sawing. Examples from Lerna suggest the former was the more likely method.

Three examples where it appears that the lower portion of the shaft has been removed by percussion may be seen on Plate 52a, b and Figures 32-3 (1a: 24, 30, 32). The open facets of the shaft are rather rough and those tool marks which exist appear to be secondary; that is, related specifically to producing the final shape of the working end. There has been little attempt to trim or smooth the opening. Percussion as a means of removing the unwanted portion of the shaft may also have been used in 1a: 31 (pl. 52c, below) and 1a: 27 (pl. 56c, below) where very little of the entire circumference of the shaft is retained at the grip end. Here the blow must have been struck downwards near one lateral edge with the bone held nearly upright (further below p. 176). Some Type 1 tools may suggest that sectioning of the shaft was effected by means of longitudinal cutting or sawing since the upper edges of the cut are regular and well-trimmed (e.g. 1a: 8-9, pl. 53a). Close inspection, however, suggests that this may well be caused by secondary trimming and not related to the initial shaping of the shaft.

Once the lower portion of the shaft had been removed, work would be focused on producing the working end, whether a sharp point as in the case of Type 1 tools or a blunt end in the case of Type 15. Since the latter usually retain the natural width of the shaft for the working end, most trimming is restricted to the lower edge which is usually cut at a slight angle to the axis of the shaft rather than wholly perpendicular (e.g. 15a: 3, pl. 53b). Few manufacture marks are ever associated with these working ends on Type 15 blunt tools since they have been lost through use. Type 1 tools with their long sharp points preserve far more marks for study since considerable trimming would be required to produce the working end, yet wear is generally confined only to the very tip. Fine, frequently parallel tool marks occur along the cut facets, the lateral edges of the shaft and underside. The amount of trimming will depend on two factors: the success of the initial sectioning of the shaft and the final desired shape of the working end. The tool marks on 1a: 37 (fig.34) show how trimming to a round tip would be achieved. 1a: 31 (pl. 52c), with its extremely long and slender tip, also shows signs of very fine tool marks on all facets of the working end. The marks cease a few millimetres from the tip where the bone becomes almost translucent and with a very high polish from wear. Whether any smoothing of the working end with abrasives took place before tools were used cannot be determined from the marks as preserved. It may be that simply through use, the working end was 'broken in' and if not entirely suitable, could be further modified or trimmed. It is conceivable that some of the apparently finished tools in our collections were never used, perhaps owing to flaws in manufacture, but this cannot be proven without recourse to micro-wear patterns.[22]

Returning to the question of manufacture marks on finished Type 1 tools it is interesting to note that very little additional modification to the shaft regularly appears. There are occasionally tool marks on the upper portion of the shaft as well as some deliberate smoothing, presumably by rubbing in sand or other abrasive. This lack of work is however, in marked contrast to the collection of bone tools of Type 1 from Lerna's neolithic contexts. Apart from their size, which is much shorter than the average bronze age example, the upper shaft is very heavily worked. (pl.118, fig.124). Even on metacarpals with their flattish section, there is usually added working on the anterior face; there are signs of working on lateral edges of the shaft and underside. The oblique sectioning to produce the working end is also heavily worked in most cases, with the pattern suggesting that a rubbing stone was employed.

A final, and not essential step in the production of a Type 1 or Type 15 tool is the trimming or smoothing of the grip end. It is clear that this did not occur in all cases and therefore could not have been vital in the use of the tool. Nonetheless, by smoothing the sharp projections of the distal epiphyses of the metapodial or tibia, greater ease in handling would certainly be achieved. In some cases it appears that the smoothness of the epiphysis is through handling rather than any deliberate working in which case perhaps a cloth was employed to protect the palm of the hand from the sharp projections. In other examples the tops of the condyles have actually been cut off, not merely smoothed as may be seen in Plate 53c (1a: 25) an uncommon example of a Type 1 tool made on a cattle metacarpal. It is worth noting that the shaft of this tool has very heavy signs of tool marks even on the upper portions indicating that a considerable amount of work was necessary to convert this kind of bone into a Type 1 tool. The signs of working on this piece together with the dearth of Type 1 tools made on cattle metapodials confirms the general hypothesis that bones were selected which required minimal modification to produce the desired finished product.

Other objects in bone and ivory

The evidence of manufacture marks on finished pieces does not extend uniformly over the entire range of bone and ivory objects from the Aegean bronze age. Bone tools, which we may assume fulfilled a primarily practical rather than a decorative function, usually retain some marks made during their fabrication. Pins, inlays, seals and other small objects which had a rather less mundane purpose are generally less informative about the methods employed during their manufacture. Least revealing of all are the larger objects, principally of ivory, relief carvings and sculpture in the round. When intact these frequently offer little information regarding the techniques used to produce them.

The Cretan seals present an interesting picture of differing manufacture methods. While the ring-shape, hammer-headed and shoulder seals give fairly definite indications as to the mode of manufacture owing to their basic shapes, often derived or dependant on the natural configuration of the material used, namely bone; larger seals of ivory rarely offer such precise information. The three classes of seals which may occur in bone, together with those in boar's tusk all represent seal manufacture in a relatively primitive stage. Not only is the shape derived from the natural material but a minimum of modification to the natural shape has been required to produce the finished object. Several motions of sawing or cutting will yield a hollow cylinder from a portion of a long bone; an additional cutting will produce a shoulder shape. Occasionally, on the hollow cylinder, perhaps destined to have a 'removable centre', drill holes for pegs are found. The drilling is however straightforward unlike that found on the larger ivory cylinders. Of the four groups, the hammer-headed seals with inserted centres and carved handles are the technologically most advanced. Yet all groups are characterised by extremely simple designs on the seal faces, often basic geometric or lattice patterns which require only minimal cutting. Tool marks, at least on the examples from Lebena discussed above (pp.81 ff and Appendix III), frequently remain. On the whole these seals reveal extremely basic manufacture methods, such as could be accomplished by anyone capable of manufacturing a bone tool. Neither special skills nor special tool kit seem indicated by the evidence of the finished pieces.

Moving to the more elaborate theriomorphic seals and the larger cylinders in ivory a completely different situation obtains. Here there is evidence of working the material in the round and, as discussed in connection with identification of materials, such seals might be cut through any number of planes in the tusk. The cylinders are not merely sections of tusks reduced in size as suggested by Kenna (Chap. III n. 1) but have been carved from prepared pieces of ivory. Preliminary shaping of the piece must be envisaged before more precise trimming of the ivory to desired shape could occur. Moreover, string-holes are the norm with these pieces and involved boring deep into the centre of the cylinder, not merely through a relatively thin wall of bone.[23] The decoration of the seal faces is often intricate with sink holes and complicated incised designs including leaves, spirals and figures, both human and animal. However, in most cases tool marks are completely obliterated, arguing for the use of very fine abrasives and a final stage of polishing.

I have argued elsewhere thet these differences in manufacture methods as evidenced by finished Cretan seals, together with the use of different materials, both local and imported may indicate chronological differences in their production.[24] At the very least one must accept that different tool kits employed by people of varying skills in working the raw materials are demonstrated. It is further interesting to note that the more elaborate seals in ivory present the same problems of interpreting evidence for manufacture methods as fine pins and plaques, while the simpler seals, usually in the locally available materials of bone or boar's tusk are much more revealing of their stages in manufacture.

The difficulty of obtaining information regarding techniques of manufacture from finished objects is well illustrated by the bone pins from Lerna. With over 300 pins from the bronze age levels of the site and many belonging to the Lerna V (MH) period, one might expect some evidence of how these pins were manufactured. As indicated above, there are no examples of rough-outs or unfinished pieces in the collection as preserved. On the finished examples one may occasionally note fine parallel tool marks rather similar to those found on the shafts of bone tools, but these are rare and generally confined to smaller, undecorated examples. Longitudinal tool marks as best illustrated on the supposed unfinished needle from Ayia Irini (pl. 40b) may also be detected on a handful of pieces. On the large fine pins with elaborately decorated heads, the quality of finish is such that virtually all tool marks have been eradicated (pl. 72-3). The shafts are fine and very straight, with remarkably uniform taper. Most traces of tool marks have been removed from around the decorated heads suggesting overall use of abrasives possibly carried on a cloth. Finally, polishing with a leather may be supposed based on the high polish of many of the finer examples.

In the case of small inlay plaques there is a similar dearth of positive information on the finished pieces regarding their manufacture. In most examples tool marks have been carefully removed, especially on the upper surfaces. Where marks are preserved, they are fine and regular, especially on the edges of the square Knossos plaques and inlay strips. The undersides are not merely left rough through working but many suggest deliberate scoring to provide a key for adhesive (figs. 27a and 112-14). This also applies to some of the wider strips and small inlays from the Citadel House.

The evidence both of the Knossos deposit and the inlays from many Mycenaean sites also suggests another element in their manufacture, that is some form of 'mass production'. Of course, such a term, with specific modern meaning must be used with caution, but can be taken to mean the repeated manufacture of nearly identical objects. Whether workmen were assigned to specific stages of manufacture only, or whether one craftsman would see an inlay through all stages of production cannot be determined on our present evidence. Nonetheless, elements of uniformity in size and shape suggest that each stage of manufacture was applied to more than one item at a time. Perhaps the most convincing evidence for this type of manufacture comes from the extremely regular and uniform appearance of the pieces. In the case of the Knossos squares (Type 56a), all measure within a few millimetres of each other (figs. 112-14). Similar observations may be made regarding the many identical Mycenaean cut-out inlays in the form of rosettes, waz-lilies, dolphins and so forth (Type 58). The uniformity in thickness of these pieces suggests that groups were all cut from a single piece of ivory worked into a flat strip or rectangle. The uniformity in size and shape suggests the use of a pattern or template as a guide for cutting out the individual objects. That a compass may have been used to outline rosettes or for the incised decoration may be suggested by wastes from the House of the Sphinxes illustrated by Sakellarakis.[25] What cannot be proved conclusively is the stage at which the Mycenaean inlays received their incised decoration. Objects which I have handled give no definite answers to this question although something may be learnt from the half finished pieces reported by Sakellarakis. In the case of the lilies which he illustrates on p. 34 (fig. 37), the centre example seems to have been cut first and bears traces of only rough and incomplete incision. However in the case of the helmet inlays (p. 28, fig. 28 centre bottom) there are signs that incision was completed before the inlay was trimmed into its final shape. Work of incising the very small rosettes and similar inlays would certainly be facilitated were they still attached to their main pieces of ivory. Pieces could be held steady for the precise work of incision. Set against this would be the danger of work wasted should mistakes in the final cutting out of the inlays be made.

Assembly and Polishing

Finished piecesmay also give evidence regarding methods of assembling objects both when a completed object has been made up from several pieces and when an object has been attached to another material. Any items which were too large or of unsuitable shape to be carved from a single piece of ivory would require assembly, presumably at an advanced stage in manufacture, possibly just before the final filing and polishing. The main categories of objects assembled from separate pieces are the larger relief plaques, some sculptures in the round and certain combs. Joining would be by means of tenons and mortises. These may also be found on some undecorated inlay strips from Knossos and the Citadel House (see fig. 27). According to Evely, the use of the mortise may be derived from the woodworkers' repertoire.[26]

Other pieces, notably sculpture in the round, seem to have been assembled by a fairly sophisticated system of dowels as may be seen in the acrobat figures from Knossos where limbs and body are made up of separate pieces. Apparently the large sculpture from the Royal Road would have consisted of some one dozen individual parts held together with dowels and pegs.[27] Pegs were also used for joining up section of ivory pyxides. In one example, that from Katsambas, sections were assembled after carving since drill holes pierce through the carved design.[28]

Ivory pegs for attachment are best represented from the Royal Road deposit. Interestingly enough, many are in position and quite often nearly intact. It is not clear whether they were inserted in the inlay prior to attachment to the box or other item or whether they are in position because they were attached to another object which then perished during the destruction of the site. In these pieces, which are also scored on the back and sometimes equipped with mortise and tenons as well, it seems that a variety of methods were used to secure the same piece in position. On the square inlays, pegs are generally confined to diagonal corners (pl. 39b and fig. 113) but on the inlay strips Type 56c pegs and peg holes are unevenly spaced (pl. 21b and fig. 118).[29]

Completed items may also preserve further information regarding methods of assembly in the form of incised signs on the undersides of objects such as inlay strips or plaques. The marks seem only to occur on such small items, never on the larger relief plaques. The principal types occurring on the Royal Road plaques may be seen on Figure 28. The sign may appear on the centre of the underside or nearer to one end than another. They occur only on the plano-convex plaques (Type 56b) although they are not present on every example. No signs or distinguishing features of any sort occur on the squares. There is virtually no repetition of the signs on the plano-convex plaques; the V and X shaped symbols do occur several times. No explanation for their occurrence seems wholly satisfactory. If they were identifying marks of individual artisans then we might expect the same symbol to recur. This would also apply if the signs were indications of the relationship of one plaque to another in the finished assembly. If they were connected to assembly in some way then we must imagine that the object to which these inlays were attached was also marked with similar signs. Why then are there no markings on the squares and strips? It might be that the plano-convex plaques which are rather more complex in shape and with varying means of attachment -

either tongues with pegs or D-shaped drilling (figs.115-17) - had to be fixed in pre-determined positions while the other inlays were fitted in afterwards.[30]

Incised marks also occur on some Mycenaean inlays although on none from the Citadel House. Sakellarakis illustrates the principal types in his figure 87. Apart from a very superficial similarity, there is no overlapping between the Mycenaean and Knossian marks, except in the V and X shaped incisions. He dismisses any relation between the symbols and the Aegean scripts and concludes that they were undoubtedly an aid in the attachment of inlays to the main object. In several examples from the House of the Sphinxes fine vertical lines are incised on the edge of the inlay corresponding to the position of the symbol on the under-side. This Sakellarakis sees as an indication that the symbols were also used to mark the position of the inlay not just in general terms in the whole composition, but to a precise spot.[31]

Of the latest stage in ivory working, namely polishing, the finished objects can give us little precise information. That is, by themselves, the objects tell us little of the methods or substances used to achieve this final stage. Indirect evidence may be provided by finds of abrasives or experimental methods (below p. 178).

TOOLS

Introduction

A further type of evidence for manufacture methods, namely tool marks, may be elicited from rough-outs, wastes and finished pieces. In theory, these marks should provide us with two kinds of information. First, we should be able to learn what sort of tools were being used; and second how they were being used in specific stages of the manufacturing process: in other words, technique. It will become apparent, that for the present at least, the evidence to be derived from tool marks is considerably less extensive than might be desired.

The question of tool marks in connection with various stages in the manufacturing process has been touched upon already. There the stages were isolated initially by the preserved shape of the piece and tool marks were used to support the contention that the segment was in an early or late stage in manufacture. Thus fine regular marks on a piece of determinate shape suggested a late stage, while heavy irregular marks on a rough block supported the notion that an early stage in working was represented. Such an approach may seem both subjective and rudimentary, yet it offers one means possible at present for eliciting information regarding the use of tools in bone and ivory working.

Before considering specific tool marks it is worth recalling some of the pitfalls inherent in their use as evidence for methods of manufacture. First, not all stages of manufacture are represented at all the sites under consideration, and there may be the temptation to integrate the evidence of tool marks from several sites to form a composite picture of manufacturing methods. Since not all of our marks are contemporary, there is the danger of attributing certain technological features to a site where they were not in fact present. Secondly, as we cannot be certain of the intended appearance of most rough-outs, which with wastes are the chief source of information about tool marks, it is difficult to determine whether specialised tools were being employed for particular end-products.

The use of tool marks as evidence for actual types of tools used is even more limited than in isolating stages of manufacture. The object is to ascertain which marks are produced by a given type of tool. Two principal obstacles are encountered in this area of study. First, a detailed knowledge of the tools in stone and bronze current during the Aegean bronze age is required. Second, a method of relating those tools to marks found on bone and ivory must be developed. The latter can only be done reliably by means of experimental techniques; while the former is beyond the scope of this study. It is significant that Evely, who had the benefit of working with stone and bronze tools for his study of Minoan crafts, was unable to make direct connections between tool marks and tools usedin the production of the workers' debris on the Royal Road. Most of his observations regarding ivory workers' tools are deductions based on his wide knowledge of tool typesand common sense rather than any specific correlation between marks and tools. Thus Evely has suggested a range of non-specialised tools including knife or blade, drill, saw, chisel andgraver as comprising the ivory workers' kit. Added to these he mentions the lathe and substances for polishing. My own observations based on the same group of ivories from the Royal Road are similar.[32] It is noteworthy that Sakellarakis working quite independently on the ivories of House of the Shields and other Mycenaean sites, but not Royal Road or the Citadel House, suggests a similar range of tools. He also believes that some of the ivory working tools may have been derived from the craft of wood-working.[33] This is a reasonable inference and may be supported by the fact that modern ivory carvers borrow most of their tools from the wood and stone-workers' repertoire.[34]

The fact that three researchers working on similar groups of material from the Aegean bronze age have not progressed beyond informed guesses regarding tools used is regrettable but not wholly surprising. Studies of bronze age Aegean technologies are still in their infancy by the standards found in other geographical areas or periods. We are only just becoming aware of the potential information to be yielded by such evidence as tool or wear marks and are as yet, ill-equipped to extract it. If we are to proceed to more definite correlations between tool marks remaining on objects and the tools which produced them we must resort to experimental techniques. The problems and benefits of such an approach will be further discussed below (p.174 ff).

Tool marks

For the present we must be content with basic observations regarding the different types of marks present both on finished and unfinished pieces of bone and ivory. Attempts to link the marks with types of tools are largely speculative. We may first begin with those marks present on bone tools from Lerna (fig. 29.1). There is nothing in the shape of the tools nor the marks preserved on them which precludes the use of stone tools, for example obsidian blades, in their manufacture. The marks are fine and fairly regular but nothing approaching those seen in Figure 29.8, 9. As described above a stone pounder of some sort could be used to break off the unwanted portion of the shaft, while the blade would have served to trim the working end. The evidence seems to suggest that only two types of implements would have been required to produce a Type 1 tool (also below n. 64).

Tools which are formed from a splinter of a long bone or rib split lengthwise would require an additional implement in their manufacture, although regrettably this is rarely discernible from the tool marks remaining. In splitting such bones a sliver of stone could be wedged in the appropriate position to be struck by the percussion instrument (fig. 30). Fine trimming to produce the quite regular marks on the lateral edges of a rib bone tool (Type 12) would be effected by a blade.

Tool marks visible on some of the Lebena seals, particularly those of bone, similarly suggest the use of stone rather than bronze implements. The rather irregular longitudinal marks running down HM 1913, the foot amulet, are almost certainly produced by a stone blade. The ring-shaped seals might also reflect manufacture with stone rather than bronze implements. Some of the marks, especially on the hoops themselves, may be caused by rather rough abrasives. This might also be the case with the marks on the edges of the large ring HM 1924 (pl. 4a, fig. 29.3). None of the designs on these seals requires anything more than a blade with the addition of abrasive.

Here it is worth recalling that obsidian is not only widely available in the Aegean but that a blade can be retouched as necessary, offsetting the possible disadvantage that it is rather brittle. Furthermore it is generally accepted that the most important cutting agent is not the blade itself, but the abrasive applied to the surface being cut. We need not assume, therefore, that even when bronze tools became available they necessarily replaced stone implements either for traditional activities such as the production of bone tools, or for the manufacture of simpler types of seals and figurines.

Whether stone or bronze tools were the norm in the manufacture of decorated pins cannot be determined. As already indicated, those finished examples from Lerna give little definite evidence as to tool marks. The supposed rough-outs from Ayia Irini (pl. 5a, fig. 29.9) are more or less contemporary and they suggest the use of a bronze tool. However since the finished purpose cannot be proven, nor is the geographical area the same, comparisons are dangerous. This also applies to the late stages of pin manufacture from the Citadel House (figs. 20, 29.4). I have been unable to determine conclusively the material of the tool used in their manufacture, although a blade or knife would be the type of tool represented by the marks. For the latest stages in manufacturing pins some sort of grinding stone may be imagined, in order to produce the fine regular shafts. From Lerna are a group of greyish sandstone objects termed 'arrowshaft straighteners/smoothers'. According to Banks, they are generally subrectangular in plan, flat on the bottom with a groove running lengthwise down this underside. The dimensions are roughly 0.10 x 0.04 x 0.03 m. with the groove under 0.01 m. wide. These objects appear in the Lerna IV period and continue into Lerna V. Banks has identified them with similar objects used by the American Indians for smoothing or straightening arrowshafts of wood or cane.[35] Without a detailed study of the wear marks on these curious implements we cannot, however, be absolutely certain of their purpose at Lerna. It should be noted that implements of this shape, made from sandstone, would be ideal in producing the round straight shafts of bone pins.

At what precise stage in the development of Aegean technology bronze tools were adopted for bone and ivory working cannot be ascertained. As suggested above, the more elaborate ivory seals are of technically higher quality than those in bone which might reflect the introduction of bronze in their production. There is however no evidence to suggest that then or later were bronze tools universally adopted for bone and ivory working. Somewhat later, during the early part of the second millenium on Crete, there may have been something of a technological revolution with the use of hard stone for seals, thus implying a more efficient tool kit. It may be that ivory carving benefitted from a wider range of tools which then became available. Indeed, the increased use of bronze could well account for the development of ivory carving into an industry in its own right, not merely an off-shoot of the traditional bone industry (below p.298f).

Evidence for the introduction of bronze tools into the bone or ivory industry at least during the MM period has been found at Mallia. R. Jullien who has studied a group of bone inlay plaques from that site states that certain evidence for the use of bronze tools may be derived from the tool marks themselves. In particular he cites the fineness of the saw marks and parallel teeth marks which could only be produced by bronze implements. In conjunction with these bone inlays was found the remains of a bronze saw.[36]

By the second palace period and in particular the LMIb ivory workers' deposit on the Royal Road, bronze tools were being used in ivory working at least. It is however, difficult to ascertain how the ivory workers' tool kit was developed. As Evely points out, the lack of examples from the preceding period makes comparisons in types of tool marks and techniques difficult.[37] Moreover, we cannot even be sure that bronze tools totally replaced obsidian blades for all stages of manufacture even on the same site. Several examples of rough-outs or wastes from Royal Road and Citadel House have signs of deep cuttings (fig. 29.6,7,8). These can be in the region of one or two millimetres deep and could be trial cuts before further manufacture took place. It is conceivable that some were made with obsidian blades although the direct evidence is slight. Nor is it clear why stone tools would be preferred for what are clearly early stages in manufacture, unless the precision of bronze tools would be reserved for those tasks where it was most needed. Indirect evidence for the use of obsidian tools in ivory carving might come from the House of the Shields and House of the Sphinxes where, according to Sakellarakis, a number of blades were recovered. They were not mentioned in the preliminary reports but Sakellarakis seems confident that they are to be associated with ivory working on these sites. Of four blades from the House of the Sphinxes, some have 'distinctive serrated cutting edges' which he associates with vigorous cutting. Unfortunately Sakellarakis does not support his assertions regarding the use of obsidian in Mycenaean ivory carving with specific examples of tool marks made by obsidian blades. Similarly since I cannot, as yet, offer positive examples of obsidian tool marks on Aegean ivories, the case must remain not proven (further below p. 178).

Some pieces of ivory do, however, offer tool marks which can be more easily linked with bronze implements. The heavy working marks illustrated on Figure 29. 7, 8 are probably the results of a fairly substantial implement, possibly a saw. Evely associates the saw with the preparatory division of the raw material as these partially finished pieces from Mycenae may be.[39] These marks are rather heavy, several centimetres long and quite regular within their individual groups, although they may criss-cross each other where directions in cutting have changed. The extremely regular spacing of the ridges on the hypothetical comb plaque (fig. 29.10) is evidence that the implement was made from bronze even though its precise form is a mystery. Finally, the extremely regular edges of square inlays, strips and other plaques are almost certainly the result of fine bronze knives (fig. 29.11, 12). Fine scoring on the underside of these plaques (fig. 29.13) could have been made with the tip of a blade, while the more irregular marks may be the result of abrasion (fig. 29.14).[40] The use of the tubular drill for peg manufacture has already been discussed. Once the basic shape had been extracted, we must envisage the final shape achieved by use of a file and possibly abrasives.[41]

Of the other tools which may well have occured in the ivory craftsmens' workshop there is even less evidence from the tool marks. Evely found little direct evidence for the chisel or graver although he suggests their use in producing undercut mortises and for removing centres from bracelets or rings. He detected the use of the chisel in the Zapher Papoura boat. Similarly it was impossible to determine whether engraving was carried out by burin, fine chisel or tip of a blade.[42]

It is further worth recalling that the blanket term 'ivory carving' tends to be misleading since a variety of techniques were clearly practiced. The tools used for the earlier stages in cutting up the tusk and preparing rough-outs and blanks may well have been identical whatever the end-product, but thereafter the choice of tools may have become more restricted. Three basic techniques in working ivory may be seen in both Mycenaean and Minoan pieces: incision, low relief carving and sculpture in the round. We should not expect the same tools to be employed in each. For the first, which is generally restricted to the small inlays [43] the design could be produced merely with a blade tip or engraving tool. The object itself would be cut out with a knife. Low reliefs and sculpture in the round would require additional tools, perhaps the chisel, in addition to the knife in order to work away the unwanted ivory. It is for the techniques of carving such pieces that the paucity of unfinished objects and the high quality of finish on completed ones present the most problems. Thus for the technically most advanced pieces we must rely on even more speculation to reconstruct manufacture methods than with the simpler items in bone and ivory for which more direct evidence remains.

We may finally consider the use of abrasives, which after all may be considered a kind of tool. Direct evidence, as mentioned is slight, although it is worth recalling the portion of hippopotamus lower canine (above p. 71, pl. 28b) where the enamel has been partly rubbed down. Since most abrasives will leave some traces on the surface of bone or ivory, a graduated series must be envisaged for pieces where little or no signs of marks remain. The chief substances would be sandstone, pumice and emery. A piece of pumice has been reported from the House of the Sphinxes which Sakellarakis associates with the ivory working on that site, although again does not offer direct evidence of its use on specific pieces. He also states that the rough skin of a certain type of fish was known to the ancients as a polishing agent for wood-working.[44]

WORKSHOPS

Another potentially important area of evidence for bone and ivory working in the Aegean bronze age is the isolation of working areas or workshops. Such portions of sites might provide examples of tools used in working the materials and stages in manufacture. The position of such working areas might also offer indications as to the relationship of the craft to the rest of the functions of the site and help to determine whether bone and ivory working was a specialised activity or one which occurred in conjunction with others. As in other sections of this discussion on manufacture methods we are hampered by lack of adequate information. This may be caused by the possibility that in older excavations, working areas, particularly those connected with bone tool manufacture were simply not recognised at the time and their existence cannot be inferred from the published records. The second problem is that in recent years a number of working areas or workshops connected with ivory carving have been isolated, but these have not yet been published in full form. Therefore one must rely only on individual pieces of ivory to draw conclusions about the nature of the workshop, rather than integrating the information of all finds and position of finds in that area. Almost nothing can be made of the location of the workshops in relation to other portions of the sites.

Outside the palace sites of the LBA we have virtually no evidence for working areas or workshops. Although a floor deposit with a number of bone objects was discovered at Lerna leading Banks to suppose the presence of a 'bone artisan's workshop', the evidence from the pieces themselves is insufficient to support this conclusion.[45] It is possible that when further study of the site records and stratigraphy has been completed, clues to bone working areas may emerge, although personally I am not hopeful. As the tool kit seems to imply, the manufacture of bone tools was probably within the capabilities of most people and one can speculate that tools were manufactured, as needed, on a household basis. This could apply to all sites, not merely Lerna. Similarly the simpler types of Cretan seals, especially the rather poor quality ring-shaped seals, suggest little or no specialisation in tools or skills required for their manufacture and these too may be random products created as desired. It is unlikely that areas of a given site would be devoted specifically to such activities.

With the production of fine decorated pins especially those known from the north-east Aegean sites in the EBA or from Lerna somewhat later in the MH period, it seems reasonable to suppose that production may have been restricted to certain individuals or households on the site. Although it cannot be proven that a substantially more sophisticated tool kit is required, such objects reveal a more controlled use of the raw material and sometimes considerable inventiveness of design. The same may be observed in the larger Cretan seals in ivory, whether cylinders, theriomorphic or other shapes. The famous ivory dove from Koumasa (HM 133) was not the product of an amateur, casually whittling away at a piece of ivory. The carver of this piece clearly understood the characteristics of his raw material and selected tools and abrasives to produce the desired finished effect. This argues for a certain degree of craft specialisation, although not necessarily restricted to bone or ivory carving alone. Indeed, the evidence from the Atelier des Sceaux at Mallia suggests that the craftsmen worked in a variety of materials, of which ivory by that time (MMIb/MMII) formed only a small part. For the Mesara we have unfortunately no excavated settlements which provided the material for the tombs. It would, however, be surprising if such as site would yield more than one seal working area per period; or even that every site produced its own seals.

By the MBA on Crete, with increasing demand for specialised objects requiring particular skills and possibly tools for their manufacture, workshops seem to have developed at least in the palace areas.[46] No such area either wholly or in large part devoted to bone and ivory working has been identified before the LBA although absence of such evidence need not imply that ivory workshops did not exist. Indeed the distribution of ivory finds argues for the existence of workshops even where no physical remains of one have been found. It is however important to draw a distinction between these 'inferred' workshops, such as that which Poursat states must have existed at Mycenae for the production of ivory goods found in the shaft graves [47] and 'actual' workshops. For the latter we must adopt a much more narrow, archaeological definition: namely, a place where goods of a particular kind are manufactured. On these criteria the number of ivory workshops in the Aegean is comparatively small.[48]

In order to identify such workshops certain items must be present. One would expect pieces of the raw material, in our case tusks or segments of tusks. Workers' waste may be another clue to manufacture of objects in a particular area of the site, as would be the presence of tools and other materials which could have been used in ivory or bone working. If, however, we were to demand that all these features be present before designating an area a workshop, then few, if any, of the so-called ivory workshops in the Aegean would merit that term.

On Crete we may suppose that each of the palace centres supported its own ivory workshop, although secure evidence is really only available for Knossos. At Zakro, the presence of whole tusks and other precious raw materials, together with finished ivory inlays (61: 16, 34, 35) strongly suggests that a workshop existed in the vicinity of the palace, although its identity is not certain. In an area thought to be a workshop were also recovered bone tools, but Sakellarakis is certainly correct in doubting that these were used in ivory working. Bone tools do occur on other sites where palace workshops have been identified, notably at Thebes (Kouropoulos plot) and the Citadel House ('Workshop area') but these seem likely to have been used in some aspect of jewellery production and were nothing to do with ivory found nearby.[49]

The workers' debris from the Royal Road, Knossos is to my knowledge unique in the Aegean bronze age. No other quantities of workers' waste have been recovered to match this and the number of finished items is considerable. While there are no positive examples of rough-outs, nor were large blocks of ivory recovered from the site, it seems that bronze tools were found in the same context as the ivory waste. A few, such as awls may have been associated with ivory working although at present this is not clear.[50] A handful of square plaques made from faience were also recovered from the same areas as the square inlay plaques. Without access to full site records it is impossible to be certain how to interpret this. It may be that the faience plaques were manufactured elsewhere and brought to the site for assembling in conjunction with the ivory inlays. In spite of the fact that the site is not yet published there can be no doubt based on the ivory remains alone that the Royal Road debris represents an actual workshop, probably a dependency of the palace itself.[51]

A second secure identification of an ivory workshop is the so-called 'artisans' workshop' on the eastern side of the acropolis at Mycenae. Hundreds of ivory chips which seem similar to those from the Royal Road have been reported, together with cuttings of gold leaf, fragments of stone, unworked quartz, blue glass paste and metal to name a few of the items enumerated in preliminary reports. There were not apparently any partially finished pieces nor are tools mentioned. Nonetheless there seems little reason to doubt that a workshop is represented, dealing in a variety of products not only ivory. It is regrettable that this site remains unpublished.[52]

Until recently, these were the only two certain examples of ivory workshops from the bronze age Aegean. Sakellarakis states that three sure examples had been identified, including the Citadel House, Mycenae. As indicated elsewhere, in my view, ivory carving may well have occurred on the site or in its vicinity but at present, it is difficult to isolate a specific place on the site as being an 'ivory working area' (further Chapter VIII).

Thanks to Sakellarakis' recent study we now have evidence which suggests the existence of two further workshops at Mycenae. In his view both the House of the Shields and the House of the

Sphinxes must be regarded as workshops.[53] Clearly Sakellarakis has reached his conclusions by studying unpublished material from these sites, including those pieces of obsidian and partially finished (or waste) fragments of ivory mentioned above (p. 136). The bulk of the ivory finds from these houses, namely the well-known inlay plaques, fell from an upstairs room according to the excavator. It was generally accepted that these formed decorations on furniture or wooden boxes. If Sakellarakis is correct in associating these with the partially finished pieces and the obsidian blades and pumice core, then the presence of so many small inlays on these sites parallels the situation at Knossos where finished plaques and waste combine to provide evidence for a workshop. Certainly the vast number of near identical inlays does suggest more than the amount of decoration to be expected in a private house, even one so near the citadel at Mycenae.[54] Undoubtedly much would be gained by a complete publication of these sites and a more detailed account of the ivory objects found there.

Two other Mycenaean centres, Thebes and Pylos present circumstantial rather than direct evidence for ivory workshops. At Thebes (Kordatzis plot: Oedipus St.) the large quantity of ivory in the burnt hoard has suggested the presence of an ivory workshop in the Kadmeia.[55] The mention of ivory on the Pylos tablets, together with the large number of ivory fragments, probably from furniture decorations and other inlays, can support the contention that ivory was worked somewhere in the vicinity of that palace.[56] To what extent other areas of the mainland supported their own ivory workshops is a matter for conjecture.

One might suppose that there was a regional centre in Attica and even one in Laconia. Nor should we assume that all ivory carving occurred in the palace centres themselves. Even if we suppose a centralised control of the ivory trade itself, we cannot be certain that the craft was totally under palace control. There is certainly some justification in seeing the known workshops at Mycenae as dependencies of the palace, but we may simply be lacking excavated evidence for ivory working at smaller settlements.[57]

From the workshops themselves we can learn only a little about the actual ivory carvers. It has been suggested that some craftsmen might have been itinerant although this has not been proven for ivory carvers. That it was fairly specialised work is a reasonable assumption, but we cannot be sure that carvers worked in that medium alone. The presence of other materials in the 'artisans' workshop' on the acropolis and of wood carvings at the House of the Shields may suggest some overlap.[58] It is, however, hard to see how it could be proven conclusively. Nor is the assertion that ivory carvers were 'royal workmen' completely unassailable.[59] This is based on the assumption that all ivory working was a palace monopoly and that ivory workers, like other craftsmen named on the tablets, were directly supported by the palace. However, since the total control of ivory carving by the palaces in Mycenaean times remains unproven, so too must the status of all ivory workers.

COMPARATIVE EVIDENCE

As has been shown above, several types of evidence may be used to re-construct our picture of bone and ivory working in the Aegean bronze age. A knowledge of the physical properties of the materials will supplement information derived from rough-outs, wastes or even completed pieces with regards to stages in manufacture. Tool marks may also suggest stages in working but rarely can they be linked to specific tools. The discovery of workshops or working areas can provide certain clues to the role of bone and ivory working during the bronze age, particularly in relation to the main palace centres. However, as indicated, in isolation no single type of evidence provides all the information we need regarding manufacture methods. Furthermore, even using all evidence available from the Aegean we are far from understanding some of the very basic questions about how objects were made and with what tools.

This situation is not remarkable in that before detailed studies of manufacture methods could take place initial study of the objects on a broad level was necessary. This includes the problems of collecting and classifying objects, eventually isolating those which would most benefit from detailed study, often employing scientific techniques. The application of more sophisticated methods of determining manufacture methods than were possible for this work should be the aim of future bone and ivory studies in the Aegean.

By far the most advanced area in bone studies is western Europe, especially for the palaeolithic and mesolithic periods. Another area which has attracted much activity is the Plains sites of North America. Since stone and bone constitute the bulk of the material remains from sites in these areas and periods, early attention to the problems of worked bone is not surprising. In general bone studies draw on three types of evidence: first, study of manufacture marks under very high magnifications; second, experimental reproductions of bone implements; and third, comparisons with ethnographic materials.

The first major application of modern technology to bone studies occured nearly twenty-five years ago when Semenov published an important study of the characteristic fabrication and wear patterns on stone and bone tools. He demonstrated that the action of one material upon another, whether for manufacture or use, would leave a pattern of marks - a micro-wear pattern - peculiar to that action and material. Thus, scraping a flint blade along the surface of a bone will leave specific marks both on the blade and the bone which will be revealed under high magnification.[60] By comparing these micro-wear patterns with ones on modern copies of ancient tools we should be able to determine both means of manufacture and function. At almost the same time as Semenov's work, similar studies were undertaken in the United States by Sonnenfeld in order to determine the function of celts.[61] Today, the study of micro-patterns in combination with experimentally produced tools is one of the most widely practised methods in bone and stone tool studies. The principal emphasis seems to remain on function rather than mode of manufacture.

In order for such methods to succeed, several points must be remembered. First a detailed study of the actual bone tools must be undertaken before attempts are made to reproduce them. Criteria for evaluating variability in size or shape of working end, even within a given type of tool must be established for eventual comparison with variations in the finished experimental tools. Thus tools of Type 1 for example, must be further classified according to the morphology of the working ends. If significant variations appear, then one must accept the possibility that either different tools were used, or different techniques employed in their manufacture. Experiments to produce all the main variants will be necessary. Nothing will be gained by reproducing only one or two examples of tools made on sheep metapodials for comparison of manufacture marks with those on Aegean examples.

Another feature of the experimental-cum-scientific approach is the need for adequate equipment. This is not merely a high powered microscope for the final study of micro-wear patterns, but also accurate copies of ancient tools. For example, in his experimental studies of palaeolithic bone work, Mark Newcomer employs accurate copies of known palaeolithic stone implements.[62] This seems a fairly obvious requirement, yet one which is not easily applied to the Aegean bronze age where bronze tools must, for some aspects of the bone industry, have been a real possibility. While the reproduction of stone tools for experimental purposes is cheap and a skill which may, in theory, be acquired by almost anyone, the acquisition of bronze and manufacture of tools in that material presents greater difficulties.

In the absence of experimental studies specifically linked to Aegean tools and end-products in bone and ivory we may, however, gain some general insights into bone working from our colleagues in other areas. After all, given the natural shape of bones which are a constant feature in all bone working, certain basic actions will produce similar results even if the tools are somewhat different. Thus, Newcomer's experiments in removing splinters of bone from an ox metacarpal might be compared to the sectioning of the deer metacarpal from Lerna discussed above (p. 121).[63]

Similarly, experiments carried out on manufacture of tools from sheep metapodials show that the lower portion of the bone may be removed by percussion and that the angle of holding the bone will affect the shape of the fracture in much the same way as suggested for the manufacture of Type 1 tools above.[64] Other experiments indicate that pre-determined percussion points may have been used to produce pointed implements from sheep metapodials.[65] Methods of splitting metapodials by inserting a splinter of stone between the distal condyles and striking it with a percussion stone have been tested, producing tools not unsimilar to our Type 4c.[66] Finally, experimental work has shown that similar implements may be produced by very different methods and stages in manufacture.[67] This should serve as a caution in attempting to draw comparisons between Aegean bone tools and those either from other geographical areas or produced experimentally.

Another approach to understanding bone tool manufacture is through comparison with ethnographic models. This is particularly favoured in North America where native Indians or Eskimos provide the modern parallels. Clearly there are dangers in drawing overly close comparisons since these modern peoples may employ tools unavailable both to their own ancestors and to prehistoric societies in Europe. Nonetheless, occasionally we can learn certain information about how bones were selected for use and how general types of tools were manufactured. One interesting fact emerges from a study of a particular kind of defleshing tool used by the Ojibwa Indians, made from a moose or caribou metapodial.[68] According to the Indians the manufacture of this tool, which has a general resemblance to our Type 15a blunt, must be undertaken very shortly after the kill, since tendons dry very quickly and make separation difficult even with steel tools. It was suggested above (p. 116) that soaking might be required in order to facilitate this stage. The working edge of the Ojibwa deflesher is produced by sharp blows from a steel axe although traditionally this is said to have been effected by prolonged rubbing on a flat surface. One significant feature which emerged from the study is something which rarely, if ever, would show up in the archaeological record. Apparently, the marrow used to be retained in the bones by means of a 'suet plug'. The marrow, so enclosed, 'is said to have provided a kind of lubrication which preserved the bone.'[69] In addition grease was applied to the outer surface of the bone toward the working end and when not in use was covered in cloth to prevent cracking or splitting. This study provides a useful example of the type of information which may be derived from ethnographic material, particularly in respect of those stages of manufacture for which we can obtain no direct archaeological evidence. Nonetheless, the application of such ethnographic parallels to problems of the Aegean bone industry is limited and only of a very general nature.

Turning to the question of ivory carving, we find that comparative non-Aegean evidence is even less easy to locate. From the tomb of Menkheperresonb dating from the New Kingdom we have representations of the very earliest stages in ivory carving, namely sectioning the tusk vertically.[70] However, most studies of near contemporary near eastern ivories tend to be of an art historical rather than technological nature. This appears to be the case for later periods and areas renowned for their ivory carvings.[71] From modern ivory carving we can learn something of the types of tools used, mainly derived from stone and wood working, but these are, as one might expect, rather more specialised than those known to have been available during the Aegean bronze age. To my knowledge, little experimental work in reproducing ancient ivory carvings has been done. As with bone, one is hampered by the difficulty in obtaining bronze copies of tools and ivory itself has become an extremely expensive commodity.

My own work has been confined to applying flint blades and abrasives to small segments of ivory to ascertain the difficulty in carving the material. The blades are not accurate copies of those available in the Aegean bronze age and therefore the results cannot be used as proof of manufacture methods. I have merely been able to confirm the view that the abrasive agent is at least as important as the cutting edge. It is, moreover, important to have some means of holding the piece of ivory steady while working, particularly in the case of small pieces.

One interesting experimental study was undertaken by Michel Dauvois in order to produce a small statuette in ivory of generalised palaeolithic type.[72] For our purposes, the most significant fact to emerge was that a dihedral burin of silex (flint) together with a piece of sandstone were alone used in producing the figure. Dauvois also noted that the small size (finished H. 0.034 m) made working extremely difficult. Indeed with the diminution in size during manufacture working became increasingly harder.

This concludes our survey of the use of comparative evidence in studies of bone and ivory working. Obviously it has been possible to mention only the principal types of study undertaken elsewhere and to refer to but a few specific studies. It is hoped that these may indicate the possible applications of the comparative approach to the problems of determining manufacture methods of bone and ivory objects during the Aegean bronze age.

CHAPTER V

FUNCTION

INTRODUCTION

Determining the function of objects found in prehistoric cultures is a matter of great importance in a study of industries and technological developments. It may give insights into occupations of the inhabitants of a site which in themselves are not preserved in the archaeological record, such as cloth or leather working, agricultural techniques and the like. The objects and the way in which they were used may give clues to the economic organisation of a site and changes in it through time. Yet a 'change to a more efficient tool kit', often invoked to explain technological or economic change, does imply an understanding of the use of objects under scrutiny. In spite of its clear importance, ironically, the determination of function remains one of the most elusive problems in archaeology and one which, until recently, was heavily dependant on imagination and subjective criteria.

In the sphere of the bone and ivory industries of the Aegean bronze age, little serious effort has been made to discuss the function of objects. Bone tools have fared worst of all. Unlike bronze tools which might have modern counterparts in steel which may serve, however inadequately, as comparisons, bone tools are exceedingly difficult to relate to a particular use. Even for the more decorative objects such as seals, inlays and relief carvings which seem to present self-evident purposes, we have little independant evidence to demonstrate their precise function.[1]

This brief chapter will evaluate the types of evidence available for determining the function of bone and ivory objects during the Aegean bronze age. Discussion will centre on the problems of bone tools which present most difficulties in interpretation yet offer the greatest scope for future work.

There are several types of evidence which may assist a study of the use of bone tools. First is the evidence which may be derived from an object itself, without recourse to scientific tests: this is limited but provides a convenient starting point for other methods. Second, there is evidence which may be provided by the archaeological context of the tool in question and its association with other types of objects. Next there is comparative evidence either derived from the bone industries in other geographical areas and periods or from ethnographic sources. Finally, evidence can be furnished by scientific studies of micro-wear patterns undertaken in conjunction with experimental manufacture and usage of reproductions of bone tools.

MACROSCOPIC EXAMINATION

We may first consider the information which may be obtained from a study of objects on a macroscopic level. This is usually preceded by classifying the objects into types for the purpose of comparison. If a morphological approach, as set forth below (Chapter VII) is adopted, a certain amount of information may be gathered from the configuration of the types themselves. This is essentially a common sense method, which cannot be carried too far. Nonetheless several basic points emerge. First, in the three chief groups of bone implements, namely pointed, blunt and serrated tools, various types of activity are implied. That is, different functions are suggested by their shapes. Hence, a wide working end would not have been suitable for piercing; while a sharp pointed end would have been useless for polishing or percussion.

As discussed in Chapter II, selection of raw materials, whether long bones, ribs or antler may also reflect different uses for the finished implement. However, since availability of specific kinds of bone may also influence distribution of tool types, we cannot assume that the use of different bones always means different functions.

The close examination of the shape of a tool should be extended to the working end, both within a given group and particular type of implement. Here we may compare the kinds of pointed working ends present within the general category of pointed objects. Clearly there is much variation, some of which may be accounted for by differing function. It is unlikely that asymmetrical tips, sharp tips and bevelled tips (see Type 3a,b,c) all had the exact same purpose, although beyond that it is rarely possible to go. We might surmise that the sharpest tips were designed for piercing actions while working ends which are definitely asymmetrical and less sharp might have been used for incision. Some blunt objects suggest polishing actions while others may indicate scraping.

This close examination of the working end, still on a macroscopic level, should also include a note of where the wear occurs. Taking Type 1 implements as an example it will be clear from the range illustrated on Figures 31-5 and Plates 52, 53a, c and 56-7 that some are distinguished by having one side of their tips much more heavily worn than the other. Generally this can be observed by the naked eye although it is not always clear in photographs. Sometimes low magnification can be of assistance. Often the actual working surface of the working end is highly polished from use. On pointed implements this may even result in a 'translucent' effect on the bone. Such observations may assist in establishing the types of action to which the tool was subjected.

Related to the macroscopic pattern of wear on the working end is the question of how the tool was held. In the case of the Type 3a tools, the location of wear demands only one method of holding the tool. That on most Type 4 implements suggests a different position of the hand. Actual handling of the tools, thus becomes a major step in the study of their use. Although human hands vary slightly in size and shape, there is no significant difference in their general configuration. Therefore, we should be able to determine, with reasonable accuracy, the manner in which the objects were held based in part on the particular shape of the tool and where the wear has occurred at the working end. From this deductions as to the use of tools may sometimes be made. Thus Type 3a tools with their asymmetrical working ends were almost certainly held between the thumb and second finger with the forefinger resting on the top of the shaft as a guide. Motion seems to have been backwards and forwards along the asymmetrical part of the working end. This is in contrast with some Type 1 tools where the epiphysis at the grip end rests quite naturally in the ball of the hand and the sharp tip, quite round in section, has a polish on all surfaces suggesting a rotary piercing motion. However, it should be noted that this tells us something about the type of action rather than specific function.

Another type of information to be gained from holding the tools concerns the question of hafting. In many of the smaller implements (especially Type 5) attachment of the tool to another material is a definite possibility. It is usually suggested by the shape and size of an implement which without hafting or insertion into a handle could only be held with difficulty. While there are few instances where incision or other alterations to the butt end of the tool give positive evidence for hafting, nonetheless Type 5 tools do suggest that some means was used to lengthen the distance between the hand and the working end. In such cases there exists what might be termed a 'thumb rest', that is a section of the tool which by chance or design seems ideal for preventing the hand from slipping downwards toward the working end. The actual presence of these 'rests' seems to be caused by the manner in which the bone was fractured during manufacture. There are rarely any signs of tool marks around the area. However, the way in which these 'rests' occur in relation to the butt and working ends cannot be coincidental. In many Lerna examples, holding the tool in the manner demanded by the wear marks on the working end involves the placing of the thumb on this 'rest'. They may also be seen on some Type 4 and 8 pointed tools.[2]

Other information about the function of objects may be derived through comparison with similar objects in other materials. In this category we may place the fine bone serrated objects (Type 32) made on split ribs. They are too thin to be handled comfortably as they exist and the shape of their butt ends often suggests insertion into a handle. Whether they were actually used as knives which they resemble cannot be proven conclusively.

Type 10 implements ('needles') form another group whose function might be implied by comparison with other objects of this shape. In fact the needle must be one of man's longest existing implements, beginning with the fine bone examples of the Palaeolithic and continuing to our own steel needles today.[3] Both shape, notably the eye, and comparison with other examples makes a reasonably secure designation of function possible for our Aegean Type 10 implements. We cannot, however, determine precise function, that is, what substance was threaded through the eye, or what material was being sewn.

ASSOCIATED MATERIAL

The study of objects found in association with bone tools has not, so far, yielded much information about the function in the Aegean bronze age. The difficulties are even greater than those encountered in isolating tools used to manufacture the bone implements. It seems likely, based on comparative evidence and the nature of the raw materials themselves that bone and antler were generally used in activities involving perishable materials which have not survived. Indeed it is the application of scientific and comparative methods to the problems of function which may yield information about this now lost associated material.

COMPARATIVE EVIDENCE

Comparative evidence falls into two categories. First is that derived from studying the bone industries of other prehistoric cultures, especially those which have been subjected to rigorous scientific examination (see below). Second, there is the information obtained from 'ethnographic parallels'. As indicated in connection with manufacture methods (above p. 176), ethnographic material is of limited benefit for our study of the Aegean bone industry. Since the socio-economic base of those 'primitive' cultures still employing bone tools today is completely different from that which obtained in our period, any attempt to compare the functions of implements must be regarded with suspicion. The principal value of studying ethnographic evidence is, in my opinion, to gain a general idea of tool manufacture and usage, chiefly those aspects which are normally lost in archaeological contexts. The greasing of tools and use of suet plugs mentioned above are good examples of this type of comparative evidence (p. 177).

SCIENTIFIC EVIDENCE

The major shortcoming of the macroscopic approach to the question of function outlined above is its inexactitude. We may learn something about the type of action to which a tool was subjected, but rarely, if ever, anything about specific function. That may only be achieved by using the evidance of micro-wear patterns as initiated by Semenov. He was surely correct in believing that these marks provide 'the sole reliable source of information regarding the use of tools.'[4] Two types of evidence can be derived from the marks: first, the pattern of marks ('geometry of traces') which provide information on how the tool was used; second, the size of marks ('topography of traces') which point to the material worked.[5]

The study of micro-wear patterns to determine function should be carried out under high magnification. The scanning electron microscope, which allows three-dimensional contours to be identified not merely two-dimensional patterns, is of great value. The micro-wear patterns on ancient tools may be compared with those on modern copies subjected to a range of specific functions for use as controls. This should allow the identification of type of action, that is piercing, incising, scraping, polishing, as well as the material which was worked, for example skins rather than cloth.[6]

There are several limitations to the scientific method of determining function. One is the very strong possibility that a single tool was used for more than one purpose, thus making isolation of patterns more difficult.[7] More importantly, for secure designation of function, every tool must be examined. There is no guarantee that a tool of a given type examined from Lerna would have been used for the same purpose as one from Ayia Irini which has a similar macroscopic appearance. Another aspect which must be considered is the availability of appropriate equipment and, most relevant in our case, the ability to move the objects to that equipment. Nonetheless, it is only through the use of the scientific approach that progress in the field of determining function can be made. It should prove to be a most fruitful line of future research in the field.

CHAPTER VI

CLASSIFICATION SYSTEMS

INTRODUCTION

One of the chief tasks of any introductory study of a group of objects linked by the use of related materials is developing a system of classification. Classification as an end in itself serves little purpose and can only lead to a proliferation of types and sub-types which may obscure important issues such as manufacture methods and function. Nonetheless, initially some form of classification or typology must be established to facilitate comparisons between objects with a view to increasing our understanding of the role they played in the material cultures of the past. As suggested above, certain observations relating to function of objects may tentatively emerge from a classification based on morphological features. This chapter will consider the purpose of establishing typologies, concentrating on the particular problems associated with bone and related materials and review the difficulties of nomenclature. Reference will be made to methodological problems encountered by colleagues in other areas. Several existing typologies for bone objects of Aegean origin will be examined. Chapter VII will present a typology for bone and ivory objects of the Aegean bronze age.

PURPOSE AND PROBLEMS OF TYPOLOGIES

The basic purpose of any typology, for whatever group of objects, is to organise and classify in such a manner as to permit easy reference to types. This will facilitate comparisons between areas and periods, and may permit observations about changes through time or between materials. While this underlying purpose of classification is present in all typologies, other factors may contribute to the lines on which it is devised. Therefore, some typologies of objects may be based on decorative or stylistic features, others on function or use and still others on simple morphological characteristics. They may be confined to objects made of a single material or cut across a range of materials.

Typologies based on decorative or stylistic features are those most familiar to students of the Aegean bronze age where they are applied to pottery. Of course, not merely painted decoration, but also fabric and shape are taken into account. Since pottery styles tend to change quickly by the standards of other materials, including stone and bone, the typologies tend to be linear. That is, they demonstrate changes over time and geographical areas, and therefore provide information about chronology. Function too may be ascertained through these typologies, at least through the distinction into fine and coarse wares, but function is not the basic criterion for the typology itself.

Functional typologies are rarely feasible with archaeological remains since the prime requirement is precise designation of function. Since the function of bone tools has not been established for the Aegean nor do they display many decorative features, a typology based on size and shape of object is the most sound for our purposes. Even adopting a morphological approach we could produce a number of different typologies depending on the ultimate use they might have. Thus, if a typology is designed merely to assist reference to a large number of bone tools in an excavation report, that is to cut excess verbiage and illustration, a typology might be fairly rudimentary. If, on the other hand, the eventual purpose of the typology is for assistance in problems of determining function in conjunction with experimental methods and examination of wear traces, a great deal more emphasis will be placed on the nature of the working ends.[1]

Scope of typology is a major question and one which has been debated in other areas of bone studies. It might be argued that since all implements of bone have one constant factor, the unchanging shape of the raw material, that a single typology for all bone objects could and should be produced. This would allow an evaluation of changes in the use of bone and methods of modifying it over a long time span. It might allow a bone object to be 'dated' based on its relation to other bone objects. It might permit interpretations of cultural links between varying areas and improve our information regarding function. Finally it is neat and systematic.

Unfortunately each of these supposed benefits hides serious pitfalls. First, bone tool types do not change with the sort of regularity which occurs in pottery. Nor does it mean much to say that notched harpoons from reindeer antler and scrapers from bison shoulder blades are not found in the Aegean bronze age. Where common types of implements such as needles do occur almost universally there is likewise little to be learnt other than a fairly basic idea of common function. Nor can much be gained by the apparent co-existence of the same type of tool in two geographical areas. Given the limits of the raw material basic similarity in the appearance of objects need not imply cultural links of any kind.[2] Finally, the universal typology taken to its logical conclusions would surely demand a proliferation of sub-types in order to account for geographical and chronological variations, making it far too unwieldy to be of great benefit.

One area where certain universal standards would be welcomed by most bone specialists is that of terminology. In France a commission was established expressly for establishing a uniform terminology and methodology for worked bone. Only the most important features of their study can be mentioned here, but it is significant that several areas of disagreement emerged from the discussion on the report.[3]

First we may consider the convention of presenting the tool working end upwards in illustrations. This is based on the fact that if one actually holds a tool by the grip end and lays it down in front of oneself, the working end will be oriented away from the body. In most publications for the Aegean bronze age bone tools have been presented working end downwards.[4] Since this has become an unspoken convention for our own geographical area I have persisted in using it. Consistency is the chief issue and there seemed little benefit to be gained in adopting a new convention.

The second issue raised by the commission was designation of the various parts of the tool.[5] It recommended that the end furthest away from the hand be termed 'extremité distale' and that nearest the hand 'extremité proximale'. The middle section would be known as 'partie mesiale'. In theory this seems ideal since a blanket term covers every working end whether pointed, blunt and bevelled and in no way implies function. Very quickly the debate on the report saw that confusion could easily arise between the use of the term 'distal end' of the tool and distal or proximal end of the bone, for it is perfectly possible for the proximal, that is butt end, of the tool to be made from the distal end of the bone (e.g. Type 1a with distal condyles at butt end). Conversely the 'distal end' of blunt Type 15b is made from the proximal end of a sheep tibia. In order to avoid this sort of confusion the participants at the conference decided that different terms must be applied, not to the ends of the tools as might be expected, but to the anatomical portions of the bones from which they were made. Thus, the distal end of a bone becomes the 'distum' while the proximal end is termed the 'proximum'. To a layman this may seem even more confusing while to a faunal expert, rather arrogant.

It is clear that one reason for the choice of distal and proximal extremities was the application of these terms in the study of stone tools. There, however, no problems arise out of orientation of the material used. Since bone tools are different from stone, and have special problems of description, it might seem wiser to select terms for use with bone tools alone. It is important to find terms which will cover the majority of tools irrespective of the shape of working end. It seems perfectly adequate to use the term 'working end' for that away from the hand since it would cover all tools apart from two groups: double-ended objects and those which display wear on the lateral edges. The former are rare, and would present difficulties with the use of the commission's terms, as they themselves recognised.[6] The term working edge should serve for the bladed and serrated objects (Types 30-32).

Rather more difficult is deciding on a term for the end of the tool nearest the hand. Several possibilities including blunt end, grip end and butt end may be considered. The first is ambiguous since some working ends are also blunt while grip end can really only describe those tools which preserve a portion of the epiphysis as a grip or handle. Hence the term butt end is suggested to describe the end of the tool nearest the hand.[7]

Questions of nomenclature are not confined to the description of parts of tools but also to types of tools. In some systems of classification names are actually given to types in place or in addition to numbers. This is not advisable since virtually all such names imply function.[8] The terms awls, gouges, chisels and spatulae all have definite meanings related to specific activities which can rarely be determined without the scientific methods discussed above. In the past, when such techniques were not available, the use of terms to describe types based on supposed function might be excused, but such a method should be avoided today. It might be argued that if such terms are categorically indicated as being conventional we might allow them. On one occasion I have followed this procedure myself (below p. 202). However the difficulties of freeing ourselves from the implied function are great and recourse to numerical designations is probably the safest.

With a fairly significant group of objects conventional terms do have rather more foundation and are consequently harder to dismiss. This includes pins, needles, toggles, beads, buttons, handles, seals and inlays. If the strictures set forth above are remembered such terms for convenience may be retained.[9]

We may now return to the question of the scope of typology introduced above. If a system of classification encompassing all worked bone is too broad to be of value, we must determine what scale is both desirable and practical. Classification could be on geographical criteria alone, in which case a typology would be devised for all worked bone recovered in the Aegean from the palaeolithic through the bronze age and down to the classical period. This may give the benefit of continuity although present the disadvantage of too broad a scope to be manageable.[10] Alternatively a chronological period of given length, for example the bronze age, might be the grounds of establishing a typology. This might assist in isolating the distribution of highly individualistic objects, but may be less informative regarding ordinary bone tools. Rather more feasible are typologies based on regions during limited chronological periods such as the upper palaeolithic in south-western Europe or the bronze age in the Aegean.

An alternative to the regional typology is that which has already been applied to worked bone in the Aegean, namely the site oriented typology.[11] In most cases the concern has been to produce an aid to organising fairly large numbers of bone objects for purposes of publication. To my knowledge, none were produced by scholars particularly interested in the problems of worked bone. We may now examine the existing Aegean bone typologies for the type of information they provide and the criteria employed in the organisation.

THERMI

First and perhaps most successful of the existing typologies is that devised by Winifred Lamb for the Thermi bone. The need for the typology was dictated by the large quantity of tools recovered from that site. Since, as Lamb notes, the majority of tools fall into well-defined types it would be unnecessary to publish each tool and fragment individually. Instead, by devising a typology she was able to show the frequency of various types throughout different periods of the site and present the results in tabular form.[12]

Lamb's procedure was to define a particular type rather briefly: 'type 1, blunt gouges often have handles like sharp gouges made from joint of the bone.' Sometimes she makes an observation regarding the distribution of the type: 'exceptional quantities lay in deposits between 5 and 3.5 m.'. A schematic drawing of the type is presented in her distribution chart while one or two actual objects together with measurements, find spot and date are illustrated. Lamb also provides comparisons from other sites where they exist.

Without wishing to denigrate Lamb's pioneer method of presenting worked bone from an Aegean site, several deficiencies in the typology must be noted. First is her use of names for types, the pitfalls of which have already been discussed. More serious problems arise from the brevity of her descriptions. We may consider her type 9 'Pins with the bone joint used for head . . so easily made that use continued through Town V'.[13] It is simply not clear, either from this description, the schematic drawing or actual items illustrated, what the type really looks like. Her first example was fairly easily located in the Mytilene Museum as its original inventory number (30. 65) was preserved and the measurements correlated closely with those given by Lamb.[14] Her second example proved more difficult to locate since the inventory number (31. 170) was not visible and there was some discrepancy in the measurements. The main problem, however, is that neither of these two examples is typical of anything. There are no parallels, even remote, for the shape of the head and size of tool. The first is a metapodial of a small animal with its shaft cut longitudinally much in the fashion that our Type 1 tools on sheep/goat long bones are made. The other tool has, it seems, only a portion of the epiphysis retained at the butt end while the central portion of the 'pin' is very slender with a round section tapering to a very fine tip. On the site there is a large number of our Type 3 objects, many made from pig fibulae. They do not really resemble either of these two objects at all, yet the description 'pins with joints as heads' could conceivably be applied to them. They are not, however, illustrated by Lamb either under type 9 or another type, despite considerably uniformity in their appearance. I have concluded that they do in fact belong to Lamb's type 9 and her illustrated examples of that type are 'atypical'.

On the whole it has been possible to correlate tools extant in the Thermi <u>apotheke</u> of the Mytiline Museum with Lamb's types even where she does not give any illustrations. This was the case with her type 4 'roughly finished pointed implements with edge of bone left on the reverse' which turned out to represent our type 5 tools made on splinters of long bones. While a typology does permit fewer items to be illustrated than otherwise, nonetheless it is important to show examples of all types, especially one so common as her type 4. Without actually handling the Thermi tools it would have been difficult to classify many of them for this thesis. Nonetheless Lamb's principal aim of presenting the worked bone in manageable fashion was achieved and is probably adequate for the purposes of the non-specialist. Her attention to the bone, even by present standards, must certainly be commended.

TROY

The aim of the bone typology for Troy likewise seems to have been an easy method of presenting large numbers of bone objects recovered from the site. The typology is confined to pointed implements only. Other objects are not so frequent and are given conventional names such as 'chisel', 'flat implements, perhaps used as spatulae', handles, beads, tubes and so forth. The pointed implements are collectively referred to as 'awls and pins' based on the assumption that 'most if not all, were evidentally used as pins to fasten garments and other pieces of fabric or as awls to make holes in such fabrics.' The typology is fairly general and is based broadly on kind of bone used in manufacture and degree of modification.[15]

Unfortunately the definitions of the types are extremely brief. Nor in fact are they very informative about the kind of bone used for a given type. Thus Troy type 1 is defined as 'leg bone of small animal: broad, flat head, usually unworked, rounded shaft, single point.' The actual bone or bones used are not given either here or in the catalogue entries for the items.[16] Type 2 appears as 'leg bone of large or small animal with or without head: natural hollow shaft; tip cut diagonally to form gouge-like point.' The difficulty here is that the definition is really too broad to having any meaning. Presumably it can encompass anything from a cattle long bone to one of the smaller mammals as well as any sort of leg bone. A (Troy) type 2 object found at random from the Troy catalogue is described as made on the femur of <u>Lepus</u> (hare).[17] Its similarity with a cattle metatarsal is limited at best. In this case a fairly general typology really offers little benefit. It does not greatly reduce the words devoted to items in the catalogue and did not, in the case of Troy, reduce the number of illustrations needed. Where they are not provided, it becomes extremely difficult to envisage the shape and configuration of a tool, especially for the non-specialist. Finally it really negates any benefits of the statistical comparisons between types which have been presented in the Troy volumes.[18] It would, for instance, be very interesting to learn whether the <u>Lepus</u> femur or other hare bones occured principally during the earliest phases of the site and whether type 2 tools made on cattle, sheep/goat or pig occurred later. However, in order to obtain such information we need to repeat laborious tabulations from the catalogue. Since not all pieces are adequately described or illustrated the task really proves impossible without access to the objects themselves.

POLIOCHNI

The site of Poliochni, in common with Troy and Thermi presented vast quantities of worked bone.[19] No totals appear in the publication but a rough count of the items yields something in excess of 1200 objects. A rudimentary typology of worked bone is presented for the principal periods of the site but no schematised drawing or distribution chart is offered. This is particularly unfortunate since with such a large number of objects some statistical comparisons between types might have been feasible. Moreover since the types are not given very precise definitions and conventional names are used rather than numbers, it is difficult to extract the information for such comparisons without access to the actual objects. For the catalogue of this thesis, therefore, only illustrated items could be safely included.[20]

The Poliochni publication does however have a number of strong points, not least the number and quality of the illustrations. Also in the description of types, reference is made to the sort of bone used in specific terms (e.g. tibia of sheep) as well as to the type of modification. The Poliochni 'typology' is not, however, so much a classification system as an admirable summary of the Poliochni bone industry.

EMBORIO

In the forthcoming publication for Emborio, the bone objects are presented in a typology-cum-catalogue.[21] Thus a type is defined and examples of that type follow immediately. Many are accompanied by illustrations. There are some 56 objects divided between 30 types. Two main categories are presented: 'end tools' and 'awls, pins, needles and idols'. 'End tools' may be either pointed or blunt and made of various types of bones. The principal order of types is based on the general shape of the bone, whether whole or split and the degree of modification to the working end. Thus, type 2 includes whole bones with sharp tips (our 1a/b); while type 3 consists of whole bones with rounded tips (our type 15a). Unfortunately no details of the specific kinds of bones and species are given either in the definitions or the actual catalogue entries but these can sometimes be deduced from the excellent drawings which accompany the catalogue. As in the case of Poliochni no typological chart is drawn up although with the relatively small numbers of items concerned and good illustrations of actual objects the need for such a chart is minimised. There is however, a chart showing the distribution of the types during various periods of the site.[22]

LERNA

Lerna has the unique position in the Aegean of having had two typologies devised for its worked bone, although the site itself remains unpublished. The first typology was devised by E.C. Banks as part of her study of the small finds from the site as her Cincinnati doctoral dissertation.[23] The second typology was devised by myself in May 1980 at the request of Professor Caskey.[24] On the whole the general criteria for the two typologies are similar but the use to which the typologies are put has influenced certain specific aspects.

Banks' approach, which is basically morphological, presents a reasonably accurate impression of the bone industry at Lerna.

The principal drawbacks lie in her definitions of types, the naming of types and the lack of clear indications about the nature of her illustrations. The first two problems are really linked. We may take as an example Banks' 'Extremity-bone awls '. This includes eight or nine separate types as defined in the present study. Indeed Banks presents her Extremity-bones in five 'sub-types' (a-e), but these are not merely variations of one individual tool type (as in the case of our 4 a-c) but actually include five very different kinds of tools. This means that even her sub-types, for example 'extremity-bone awls (d)' include an enormous range of tools. Very broad definitions of types demand fairly lengthy descriptions in catalogue entries to provide even basic information about the appearance of the items.[25] Banks' names for her types are in part conventional: awls, scraper/polishers knives and so on but qualified by the type of bone used to make the tool. This is clearly better than reliance on conventional names alone but does result in rather cumbersome designations. Of course some people may find numerical designations alone equally difficult to use.

The other drawback with Banks' typology and catalogue is the fact that no schematic drawing of types is presented. Although not made clear in her text, the illustrations of bone tools are in fact rough outline drawings of actual objects found at Lerna although they are not identified by inventory numbers.[26] No accurate drawings of individual objects are presented.

It should be stressed that with Banks' and the other typologies discussed above, criticisms are not made either to denigrate the decision to present a typology nor the individual who produced it. On the contrary, the point of studying a variety of typologies is to let us to adapt certain positive features into any new system constructed for Aegean bone tools and avoid any pitfalls which often emerge only when people other than the authors try to use the system. Sometimes the drawbacks in a given type of typology exist because it is designed only to give the minimum amount of information required for publication rather than to provide the basis for future specialist study.

LERNA AND AYIA IRINI

Differences in organising typologies, even by the same person may be illustrated in those which I have drawn up for both Kea and Lerna. In the case of Ayia Irini I was encouraged to draw up a typology along the lines of Troy and Lerna (Banks) by Professor Caskey.[27] Thus features of both typologies appeared. Conventional names such as awls, and gouges were in part, retained although it was made clear that these terms were not intended to imply function (see Appendix IVa). The types are however numbered. It is easy with hindsight to recognise that numerical designations alone should have been given to the types. As with all the other Aegean bone typologies there is no chronological progression in types, nor does one type develop out of another. What is reflected in the typology is the degree of modification to the original type of bone. Thus Kea type IV owes its place in the chart to the fact it is a splinter of long bone considerably modified from the raw material. Type VII serrated 'knives' follow type VI 'rib bone awls' because of the similarity of bones used. Blunt objects are classed together while needles, and pins fall at the very end in the fashion of Troy.

With the Lerna typology I was able to abandon the conventional names and merely present the objects under major groups such as 'pointed objects', 'blunt objects' and so forth (see Appendix IVb).[28] Definitions are somewhat more precise in respect of bones used and nomenclature. For example I have replaced the term 'cannon-bones' used in the Kea typology with 'metapodials' in the new Lerna classification. A number of Banks' old types have been divided up to reflect more accurately the differences occurring in the tools. This occurs principally in the introduction of Type III(a-b) and IV(a-c) in the manner of Kea to distinguish between the variety of tools made on portions of metapodials.[29] There is a marked similarity between this new Lerna typology and the Aegean typology presented in the following chapter due largely to the fact that most types present at Lerna are found elsewhere in the Aegean. In a few cases however, where there is justification for defining a 'type' based on only one or two examples at Lerna, it has been decided to relegate those items to one of the 'unclassified' groups (Type 14, 29) in the Aegean typology.[30]

CHAPTER VII

THE TYPOLOGY

INTRODUCTION

The aim of this typology is to organise the large number of objects in bone and related materials from the Aegean bronze age into some sort of comprehensible format. A strictly morphological approach has been adopted for the majority of items and conventional names have been kept to a minimum. Most types have been identified as a result of first-hand inspection of objects. Fortunately, the collections of Lerna and Kea offer examples of a wide range of types and it has rarely been necessary to define types solely on the basis of published photographs.

Most attention in devising this typology, as in the accompanying Catalogue (Appendix I), has been devoted to implements of bone and antler and rather less to more familiar items such as seals and fine ivories for which specialist catalogues already exist. Seals have been relegated to a single type although subdivided according to shape. For Mycenaean ivories extensive reference is made to Poursat's study and catalogue in order to avoid unnecessary repetition here. Emphasis is chiefly on form rather than motif.

Further details about the approach to individual types will be found under the headings below and on the introductory pages to each type in the Catalogue. Technical terms are explained on pages xvi f. of the Catalogue.

This typology is not sequential: that is, Type 2 has not developed out of Type 1 and so forth. It is unlikely that such a method could be applied to worked bone in the Aegean or elsewhere. There is, however within each main group of objects a general trend from types showing very little modification to the natural shape of the material to types which are heavily worked. Thus within the group of pointed objects made on long bones Types 1-3 are made on whole long bones, 4-5 on split long bones; 6-9 on splinters of long bones and 10 and 11 ('needles and pins') where the natural shape of the material, whether long bone or ivory, has been eradicated.

In this chapter a full definition of each type will appear followed by a short discussion of any peculiarities of the type, distribution or individual objects. In the interests of space such comments must be brief as must mention of comparative material. Both distribution tables and comparative material appear on the introductory pages of each type in the Catalogue. The latter is confined to Thessaly and Macedonia, Ayio Gala and the pre-Troy I phases of Emborio (VIII-VI), Poliochni (Black), Troy (Cincinnati excavations only), Knossos neolithic and Saliagos. Some material from the neolithic period of Lerna may be seen on figs.124-25. For the late bronze age comparative material is derived from the later phases at Troy and occasionally Delos, although in view of the problems connected with the Artemision deposit, reference to Poursat (Iv.Myc. p. 152 ff) is essential.

A few general words may be addressed to the use of distribution tables in the Catalogue and discussion regarding distribution of items within a type in this chapter. The number of items in the tables represents the number of items (as opposed to entries) found in the Catalogue for that type. In certain instances, notably Thermi, the number of non-catalogued items is also included, but this is clearly indicated in the table. The tables are not reliable guides to the absolute quantities of objects recovered from the regions. The N.E. Aegean would display much higher numbers for many types had it been possible to catalogue every single item from Poliochni (see Introduction to the Catalogue). Regarding relative frequencies the difficulties should be clear from a consideration of loss of material and sampling bias. The principal reason for including such tables at all was to provide an easy indication of the general areas or periods where the catalogued items occur as well as to provide the basis for discussion regarding the possibility of the introduction of new types or the abandonment of others.

GROUP I: POINTED OBJECTS

The objects in this class are all characterised by a pointed working end. The majority of types (1-9) are made on long bones, either whole or portions thereof while a further 2 types (10-11) are generally made on segments of long bone or occasionally ivory. Type 12 consists of objects made from rib bones split lengthwise and Type 13 of objects made from segments of deer antler. Objects which cannot be placed in any of these types are found under Type 14.

The objects have a great variety of working ends. Some of these may be relatively blunt. The shape of the working end is not the sole basis for definition of type. Thus two objects may have similar working ends but are included in two separate types because the bone or segment of bone is otherwise different.

Type 1a: Definition Fig. 31-35; pls. 52-53, 56.

1. Made from whole long bones of small animals, usually metapodials or tibiae of sheep/goat. Radius occasionally found. Other species include pig, hare (rare and atypical); and cattle.
2. Epiphysis usually preserved at butt end for grip. Sometimes smoothed from use or deliberately cut down. Distal epiphysis of metapodials common; also distal epiphysis of tibiae.
3. Entire circumference of shaft (diaphysis) retained for varying lengths but ca. $\frac{1}{2}$ - $\frac{3}{4}$ length of tool most common. Below shaft cut obliquely or longitudinally toward working end.
4. Working end usually round in section with fine tip.
5. Ave. dims: L.0.08-0.010 W.ca.0.01 Th. (ant-post) 0.012.

Type 1b: Definition Fig. 35; pl. 57.

1. Bones and treatment of epiphysis as for 1a although sheep/goat predominate.
2. Entire circumference of shaft (diaphysis) retained for most length of tool - usually ca. $\frac{3}{4}$. Below - shaft cut longitudinally to form working end.
3. Working end triangular in plan, short and stubby with rather blunt tip.
4. Ave. dims: L.0.05-0.07. W.0.012. Th. (ant-post) 0.012.

Type 1a/b: Comment

This type has already been discussed in connection with selection of materials (p. 14) and manufacture methods (pp. 15 and 145). The type may be easily recognised from photographs although identification of the species and bone may be more difficult. Within the type there are no significant variations from one region to another although the occurrence of items made from hare long bones is rare outside the North-east Aegean. This may be pure chance.[1]

The most homogeneous group consists of items from Lerna IV although the first appearance of the type at that period is not necessarily to be assumed (below pp. 275).

Working ends fall roughly into two groups: those which are very long and fine with a sharp tip and others which are much flatter in section and have a slight bevel to the underside.

Type 1b presents several problems with interpretation. The Lerna examples come from mixed fill deposits (Lerna II-III) including a proportion of neolithic sherds. The possibility that these Lerna objects (1b: 8-10) may be of neolithic rather than Lerna III date may be supported by their similarity to the neolithic examples illustrated on Figure 124 and Plate 118. Generally neolithic tools made on whole long bones are heavily worked especially on the anterior and to a lesser extent the posterior facet. Sometimes the lateral edges of the whole shaft are also trimmed as on 1b: 8.

<u>Type 2a: Definition</u>

1. Ulnas of cattle with little modification except at working end.
2. Epiphysis preserved at butt end, apparently untrimmed.
3. Working end formed from the distal portion of diaphysis; rather blunt.
4. Ave. dims. L.<u>ca</u>.0.12 W.<u>ca</u>.0.025.

Type 2b: Definition Fig. 36; pl. 58a.

1. Ulnas of sheep/goat or hare.
2. Epiphysis retained at butt end, may be trimmed.
3. Little modification to shaft except at working end. Tip may be quite sharp.
4. Ave. dims. L.0.06-0.08 W.ca.0.012.

Type 2a/b: Comment

The identification of Type 2a for the Aegean bronze age rests on a sole example from Poliochni. Similar objects were, however, manufactured during the neolithic. A large number of cattle ulnas were recovered from the Knossos neolithic excavations although not all preserve their working end and may never have been used.[2] The rarity of blunt objects from cattle ulnas (Type 16, p. 228) during the bronze age may also be noted. This seems to be one of the few clear-cut cases of a bone tool in use during the neolithic being abandoned before or early in the bronze age.

The use of sheep/goat ulnas is similarly rare although more examples exist. It should be noted that in addition to the example from Ayia Irini included here, several more fragments of worked sheep/goat ulnas were recovered but their condition does not allow classification with this type. It is always possible that more examples of this type exist but were not recognised as worked bone during excavations without the assistance of a faunal analyst.

Type 3: Definition Figs. 36-38; pl. 58

1. From fibulae of pigs with little modification except at working end.

2. Butt end formed by distal end of the bone. Epiphysis sometimes present, although in most cases bones with unfused epiphyses used. Further trimming may occur.
3. Little modification to diaphysis except toward proximal end of the bone. At the point where the bone begins to flare out the diaphysis is cut off to form the pointed working end of the tool.
4. Three principal variations of working ends may be observed and constitute sub-types described below.
5. Ave. dims. L.0.06-0.10 W.0.007-0.008. Th.<u>ca</u>.0.005.

<u>Sub-types</u>

a) Working end cut obliquely to main axis of shaft. Wear on underside of asymmetrical tip.
b) Working end round in section, gradually tapering to fine tip, often sharp.
c) Working end rather blunt and sometimes bevelled. Tip rather flat in section and triangular in plan.
d) Objects which are lacking their working ends but on basis of bone and modification suggest classification with this type.

<u>Type 3: Comments</u>

This type has been discussed above in connection with selection of materials (pp. 21-2). The type is not easy to recognise from photographs which may account for the small number of examples other than those from Lerna and Thermi.[3] For its possible use at Troy see above p. 21, and n.25. As indicated in Chapter II the limited distribution of this type presents great problems for interpreting its distribution. Factors such as methods of butchering the animal might affect the availability of this bone for use in tool manufacture.

Type 4a: Definition Figs. 39-41, pl. 59.

1. From long bones of cattle or deer (occasionally pig or even sheep/goat), generally metapodials. Split lengthwise.
2. Ca. $\frac{1}{2}$ - $\frac{1}{3}$ of epiphysis retained at butt end as grip, sometimes further trimmed or smoothed.
3. Below butt end lateral edges of shaft heavily worked and taper toward working end. At mid-shaft tool may be rather flat in section but becomes rounder toward tip.
4. Tips vary from very sharp to rather rounded and blunt.
5. Ave. dims: L.0.09-0.15 W.0.015-0.03 Th.ca.0.008. Nb. some examples made from deer metapodials may exceed L.0.20.

Type 4b: Definition Fig. 42, pl. 60

1. From long bones of sheep/goat (occasionally pig and cattle, much trimmed), generally metapodials. Split lengthwise.
2. Treatment of epiphysis, shaft and working end as above.
3. Ave. dims: L.0.05-0.09. W.0.01-0.015. Th.0.005-0.008.

Type 4c: Definition Fig. 43, pl. 60.

1. From metapodials of sheep/goat or cattle split lengthwise through distal condyles.
2. Remaining condyle preserved as grip.
3. Treatment of shafts varies, examples on sheep/goat usually display parallel lateral edges for much of length with only last $\frac{1}{4}$ cut to working end.

4. Working ends usually rather blunt and sometimes bevelled on underside.
5. Dims. vary according to bone: L.0.05-0.10. W.0.01-0.025.

<u>Type 4 a-c: Comment</u>

The method of manufacture of these implements has been discussed in Chapter IV (pp. 122, 176) and illustrated in figures 18 and 30. Most examples of this type are extremely well made and carefully finished. Some are provided with 'thumb rests' (marked with an 'X' on the drawings).

The majority of catalogued items occur in EBA contexts although it is difficult to determine whether this reflects a genuine falling off of the type or is merely a problem of sampling.

Type 4c presents other problems of interpretation. The Lerna examples (4c: 7-8) are from mixed fill; 4c: 9-10 might be from contaminated IIIc and IVb contexts. The similarity of these pieces to examples from the neolithic levels on the site should be noted (cf. fig. 124). Certainly the heavy trimming of tools appears to be a feature of the Lerna neolithic industry.[4]

<u>Type 5a: Definition</u> Figs. 44-46; pl. 61.

1. From splinters of long bones of cattle (sometimes pig, rarely sheep/goat); metapodials and tibiae, although a high proportion are unidentified.
2. <u>Ca</u>. $\frac{1}{4}$ - $\frac{1}{3}$ circumference of bone retained at butt end, occasionally with segment of epiphysis preserved, although often butt end is jagged. It is not always possible to tell whether this is deliberate or result of breakage.

3. Lateral edges may remain parallel for ca. ¾ length before tapering to working end but others taper almost uniformly from butt end to tip.
4. Working ends vary but tips usually round in section and may be quite sharp.
5. Ave. dims: L.0.06-0.10. W.0.015-0.02. Th.ca. 0.01.

Type 5b: Definition Figs. 47-51, pl. 62.

1. From splinters of long bones of sheep/goat (occasionally pig).
2. Modifications as above. Some examples very slender with sharp tips. Lateral edges rather more irregular than 4a.
3. Working ends vary but tips round in section and may be sharp.
4. Ave. dims: L.0.04-0.07. W.0.005-0.01. Th.ca.0.005.

Type 5a/b: Comment

This is one of the most common tool types found in the Aegean. The majority of examples are of sub-type b. In general the broader examples made on cattle long bones are rather more carefully worked than the smaller examples. In both sub-types it is often difficult to determine whether the butt end is intact. Some with jagged ends may have been hafted or inserted into a handle. Many examples are provided with 'thumb rests' (p. 184).

The distribution chart showing a predominance in the EBA is hard to dismiss. The Thermi examples have been discussed above. Most of the mainland examples come from EHIII contexts at Lerna where the type continues into period V.[5] The extremely low number for the mainland in the LBA is difficult to explain and could reflect a decline in the type. However these tools are so small and unexceptional that they might well have been passed over in publications in favour of more striking or valuable objects.

Type 6: Definition Figs. 52.53.

1. Splinters of long bones, species rarely determinate but probably sheep/goat or cattle.
2. Shaft rather irregular but ca. triangular in section.
3. Slight flattening at butt end may indicate hafting; shaft tapering irregularly to pointed working end.
4. Ave. dims: L.ca. 0.04-0.08. W.0.005-0.008.

Type 6: Comment

Most of the catalogued items come from Lerna and no published examples are included.[6] Without clear drawings of sections it is impossible to isolate this type in published material.

Few of the examples are carefully worked except at the working end itself. It is likely that these tools were made from rough splinters of bone, perhaps waste from other processes.

Type 7: Definition Figs. 54-55; Pl. 63.

1. Splinters of long bones, species rarely determinate but probably sheep/goat or cattle.
2. Both ends of the tool pointed although not always clear if both were used. One may have been inserted into a handle.
3. Shape of shaft varies considerably: may be ca. triangular in section as Type 6, round in section, or even preserving some of natural concavity.
4. Ave. dims: L.0.04-0.08. W.0.003-0.01. Th. less than 0.005.

Type 7: Comment

Apart from the numerous examples from Poliochni and a good group from Thermi the type is rather infrequent.[7] This was also noted by the authors of the Troy typology. Some examples may of course remain unidentified among tools with their butt ends broken off. As noted above few examples give definite evidence that both ends were used for working. Traces of polish on the second pointed end could be caused by handling or hafting. Apart from their general shape there is little to set these off from other small implements such as Type 5 or 6. That is, from their shape alone there is very little indication of specialised manufacture.

<u>Type 8a: Definition</u> fig. 56; pl. 64.

1. From segments of cattle long bones.
2. Shaft heavily worked to produce flat section, very little trace of concavity remains. On lower portion of shaft may be a 'thumb rest' (p. 184).
3. Toward working end, shaft becomes round in section, tapering toward symmetrical point.
4. Ave. dims: L.0.08-0.10. W.<u>ca</u>.0.015. Th.<u>ca</u>.0.006.

<u>Type 8b: Definition</u> fig. 57-58. pl. 65.

1. From segments of long bones, some sheep/goat but not always identifiable.
2. Modifications as above, but thumb rests not common.
3. Taper generally confined to lower $\frac{1}{3}$ of tool; tips may be asymmetrical and bevelled.
4. Ave. dims: L.0.05-0.08. W.0.004-0.01. Th.0.002-0.005.

<u>Type 8a/b: Comment</u>

All items in the catalogue are unpublished owing to the difficulty of isolating this type from published illustrations. Most of the examples are carefully worked on all sides to produce the very flat section, especially those under sub-type 8b. The principal distribution of this type in the EBA on the mainland simply reflects the bias of the Catalogue towards unpublished material, in this case from Lerna.[8]

Type 9: Definition fig. 59-60.

1. From segments of long bones, either sheep/goat or possibly cattle.
2. Small portion of natural shape of bone preserved at butt end or 'head'. Sometimes trace of concavity continues down shaft for short distance.
3. Shaft heavily worked to cylindrical, pin-like appearance. Tips often sharp and fine.
4. Ave. dims: L.0.08-0.10. W.ca.0.01 (at 'head').

Type 9: Comment

This type is often difficult to isolate from photographs alone. Nonetheless a large number have been included in the catalogue from Poliochni where the examples are said to resemble 'needles' without the piercing. As many of those are described as made from sheep/goat diaphyses it seems that the identification of the Poliochni examples with our type 9 may be justified. The Thermi examples are not included in Lamb's typology *per se*, although it is possible that she viewed them as belonging to her type 9 'pins with joint used for heads.' (see also pp. 195 ff). In some of the more heavily worked examples the distinction between these and some of our Type 11a 'pins' is slight.[9] Whether they were used as a tool or a 'pin' cannot of course be determined.

Type 10a: Definition Fig. 61; pl. 66.

1. From small leg bone, e.g. pig fibulae or sheep/goat ulna.
2. Epiphysis often little modified except for perforation which may be quite large (d. ca. 0.005)
3. Rather short broad shaft ending in blunt point.
4. Ave. dims: L.ca.0.05. W.0.01-0.015.

Type 10b: Definition Figs. 61-62; pls. 66-67.

1. Bones usually as above; also segments of long bones similar to type 9.
2. 'Head' or butt end perforated and distinct from shaft. Where pig fibulae are used, butt end resembles that of Type 3 (distal end of bone, epiphysis removed).
4. Cylindrical shaft by mid-point, tapering to fine tip.
5. Dims. vary considerably L.0.05-0.10. W.(head) 0.006-0.01.

Type 10c: Definition Figs. 62-63; pl. 67.

1. Materials vary: some heavily worked segments long bones (e.g. metapodials); occasionally pig fibulae with head much trimmed; antler; ivory.
2. 'Head' or butt end perforated. Hole may be very small (D.ca.0.002). Head not set off from shaft.
3. Shaft may be rather flat and sub-rectangular near head but becomes cylindrical toward working end. Fine tip.
5. Dims. vary considerably: L.0.04-0.10. W.(head) 0.003-0.007.

Type 10 a-c: Comment

Although the sub-types vary considerably in appearance these items are grouped together because they are all perforated near the butt end.[10] Those presented in sub-type a have blunt points and it seems unlikely they could have been used for piercing. They are sometimes called 'bodkins' in published sources. The items included in sub-types b and c are frequently termed 'needles' because of their similarity to modern examples. Again, whether all could have been used as needles, that is for sewing, must remain open owing to the width of their heads (especially sub-type b). The use of antler for an example from Ayia Irini (10c: 2) and ivory for several examples of LHIII date (10c: 11, 12, 21) should be noted.

Type 11 (pins): Definition

1. From large segments of long bones, usually cattle or deer; ivory also encountered. No certain examples of antler yet isolated.
2. Where bone used, diaphysis heavily worked so that all trace concavity removed. Butt end or head may vary considerably and forms basis for sub-types a-e (below).
3. Shaft cylindrical and generally displays uniform taper to fine tip. Many examples well polished.
4. Dims. vary considerably: L.0.05-0.20. D.head. 0.003-0.008.

Sub-types

a) Plain heads. Head not distinguished from shaft; may either be cut off flat and at right-angles to shaft; or slightly rounded. Figs. 64-65; pl. 68

b) Simple heads. Head distinguished from shaft. Head consisting of only one element and may be conical, mushroom-shaped or nail-shaped. Figs. 66-69; pls. 69-70.

c) Decorated heads. Head consisting of more than one element. These may be series of grooves and toruses, conical or biconical forms, bead, barrel or vase-shaped elements. Several elements may occur in combination. Also bird-headed and hammer-headed pins. Some examples unique. Figs. 70-72; pls. 71-74.

d) Hooked pins (Shepherd's crook pins). Shaft curves to form hook at head end. Usually ivory. Fig. 73; pl. 75.

e) Undiagnostic fragments. Cylindrical portions of shaft, usually preserving the tip which may come from pins, although some could be the working ends of pointed implements.

Type 11 a-e: Comment

Bone pins whether plain or with carved heads are a well-known occurrence on most Aegean sites. Only Crete presents a rather blank picture for this type of object. They have not been reported from any pre-palatial burials although metal pins do occur. This dearth of pins continues into the MBA on Crete in marked contrast with other areas in the Aegean during the EBA and MBA. However, pins both plain and decorated have been reported from palace period contexts and one might suspect that the others have never been published. A large number of pins from Evans' excavations at Knossos were discovered in 1978 (see Appendix IIa) and while some are clearly post-Minoan, others may well be of bronze age date. The shepherd's crook pins do seem to have been a Minoan 'fashion' from pre-palatial burials onwards and it is interesting that now examples have been discovered in bone and ivory. Dr. Imma Kilian has confirmed that this seems to have been one of the few occasions where a metal type has been transferred to bone or ivory.[11]

The sites of the North-east Aegean have produced some fine pins forming one of the most distinctive features of their bone industries (below p. 271). Those from Poliochni tend to be of simple-headed variety, while Thermi offers a number of extremely elaborate and inventive heads.

Pins occur in the Cyclades but the low number recovered probably reflects the amount of excavated material from settlements (below p. 316). It is therefore difficult to generalise about local features, apart from noting the bird-headed pins from Syros or the pins with incised decoration from Ayia Irini which seem to be a local style (below p. 280).

As mentioned elsewhere Lerna provides one of the richest groups of pins in the Aegean bronze age and represents the majority of catalogued items for the EBA and MBA on the mainland.[12] Most are from the Lerna V period and include some of the finest examples of sub-type c, both in conception and execution. According to Dr. Kilian the fine bone pins of the mainland owe nothing to bronze pin types.[13]

After the fine sequence of the MBA, pins from most Mycenaean contexts are fairly standard ventures with heads composed of a series of grooves and toruses. There are few instances where several forms appear in combination. Apart from sub-type c with grooves and toruses, the most distinctive form of this period is the bulbous-headed pin. This may be undecorated as in 11b: 92, 93 or surmounted by grooves and toruses (11c: 6, 79). These seem to begin in the LHIIIb period and in the view of Dr. Kilian provide 'forerunners for the sub-Mycenaean - protogeometric metal types' (with bulbous heads).[14] Pins with incised decoration of concentric circles and dots also appear late in the Mycenaean period (?LHIIIc).

We have little evidence that ivory was used for pin manufacture before the LBA although this may be caused by our lack of Cretan material. However even in the Mycenaean period ivory was not universally adopted for pin manufacture even within the palace complexes. Of roughly 30 catalogued pins from the Citadel House, only one is ivory (11e: 21). It is quite possible that like Cretan seals, a number of pins published as ivory are really bone. In my view, ivory, with its lower collagen content and therefore lower resilence, coupled with natural lines of fracture makes it ill-suited for use in pins. Although these would presumably be subjected to less stress than an ordinary bone tool, the characteristics suggest that ivory was not a practical alternative for pin manufacture. It is further interesting to note that apart from the hooked pins, there is no appreciable difference between the shape of head in bone and ivory examples. That is, carvers did not exploit the freedom of restrictions in material offered by ivory to carve larger or more elaborate heads. Ivory pins are therefore merely copies of bone types in a material which was more costly.

<u>Type 12: Definition</u> Figs. 74-76, pl. 76

1. From rib bones, usually of cattle but also deer.
2. Portion of bone split lengthwise to yield very flat section of solid bone with cancellous material on underside.

3. Upper surface may be worked and cancellous material smoothed from underside. Lateral edges usually cut neatly. Shape of working ends form basis for sub-types (below).
4. Ave. dims: L.ca. 0.05-0.09. W.0.015-0.02. Th.0.002-0.004.

Sub-types

a) Working end long, cylindrical in section tapering to sharp tip. Usually found on tools of ogival shape but also some with uniform taper.
b) Working end rather short but quite sharp not articulated from rest of tool. Lateral edges of tool often parallel for ca. $\frac{2}{3}$ length, then taper uniformly to working end; in some cases, taper begins at butt end.
c) Double-ended. Tool ca. lozenge-shaped, working ends may be similar to a) or b).
d) Examples which cannot be placed in the categories above.

Type 12 a-c: Comment

This type is discussed below in connection with the sites of Thermi and Lerna (Chapter VIII) and also on p. 319 f. (See also Chapter II).

The distribution of tools made on split ribs causes a number of problems in interpreting the evidence. Superficially this looks like a clear case of a type being linked to a single, albeit lengthy, phase of the Aegean bronze age. The Lerna examples are from period III (EHII) contexts not Lerna IV which may betray greater affinity to the MH culture than to the preceding (below p.273f).[15] At Kea where few objects of EBA date were recovered owing to later structures, EB room IV yielded three of these implements. Large quantities of this type were recovered from the North-east Aegean sites of EBA date. For once, Crete does yield examples of this type, but ironically, from MBA contexts (Mallia and Phaistos), our only examples of MBA date.

Whether the use of rib bones reflects conscious selection for their particular characteristics cannot be proven. It may do so since at Poliochni and Lerna at least the numbers of this type are comparable to Type 5 (especially 5b) tools on segments of metapodials. The latter rarely have such fine sharp working ends as our Type 12 examples, in particular 12a.

It is even more difficult to explain the apparent cessation of this tool type. It might have been replaced by tools made on other bones, possibly because of a change in butchery techniques.

At Lerna one might see them replaced by Type 1 tools in the Lerna IV period, but I personally am not satisfied that Type 12 belongs exclusively to Lerna III, or that Type 1 does not begin until Lerna IV (see also below p. 275). In the North-east Aegean Type 1 tools occur at the same time as Type 12 but in smaller numbers. It is of course possible that they were replaced by a metal type or even that the occupation which they were used for ceased to exist in the Aegean bronze age.

<u>Type 13a: Definition</u> Figs. 77-78; pl. 77.

1. Long segments of antler main beam or possibly tine.
2. <u>Ca</u>. sub-rectangular at butt end. Underside preserves cancellous material; upper surface usually with natural furrows of antler cortex except where worn smooth at butt end and near working end.

3. Lateral edges irregular but ca. parallel for most length gradually tapering to working end. Tip often rather blunt.
4. Ave. dims. L.0.10-0.20. W.ca. 0.015. Th.ca.0.005.

Type 13b: Definition Figs. 77-78, pl. 77.

1. Segments of antler main beam or possibly tine.
2. Heavily worked, butt end ca. rectangular in section; cancellous material remains on underside but upper surface smoothed.
3. Lateral edges parallel for ca. $\frac{2}{3}$ length, remainder cut to triangular working end; tip round in section, not sharp.
4. Ave. dims: L.0.08-0.10. W.ca. 0.01. Th.ca. 0.005.

Type 13a/b: Comment

The distribution of this type in the LBA is most interesting. Most of the sub-type a examples come from the Citadel House, Mycenae and some may be connected with activities which took place in the Workshop area (above p. 169 and below p. 287) although at present it is impossible to be more precise. A further example with significant associated material is that already mentioned from Thebes (13a: 11). The precise nature of the context of the Kea piece is not yet known apart from its late date (Kea VII and VIII). Unfortunately the three examples of sub-type b from that site are still undated. The Lerna examples (13a: 2 and 13b: 4-6) are of interest in that they are some of the few implements recovered from period VI where no settlement deposits, as such, were excavated.[16] It is of course impossible to determine precise function but the rather blunt tips, especially those of sub-type b) suggest that piercing would not have been possible with these tools.

Type 14: Unclassified pointed objects Figs. 79-81, pls. 78-79.

A great many bone tools which appear in the publications cannot be classified according to type either owing to poor photographs or inadequate descriptions. Sometimes it is not even clear whether they have been made from rib bones or long bones. To catalogue all of these would serve little purpose so an abbreviated format has been adopted in the Catalogue.[17]

In any system of classification it must be remembered that types are arbitrary inventions. Naturally it is hoped that they will reflect as nearly as possible the kinds of material being described, but one must recognise that many objects are unparalleled and defy classification. Bone tools are no exception and many examples occur which fall outside the principal types as defined here. Some may be quite carefully worked while others could better be termed 'casual points'. In these cases, a piece of bone, perhaps only a splinter shows only slight modification and then only near the working end. All such items are grouped together under Type 14.

GROUP II: BLUNT OBJECTS

The objects in this group are all characterised by a blunt working end, often broad and flat. They may be made on whole long bones or segments thereof (Types 15-18); ribs (19-21); or portions of antler (22-23). Other blunt objects have been classed solely on their shape which may occur in either bone or antler (Types 24-26). Types 27 ('Spoons') and 28 ('Cosmetic spatulae') occupy the same place as pins do in relation to pointed objects and may occur in ivory as well as bone.

Type 15a: Definition Fig.82 pls. 80, 82.

1. From whole long bones of sheep/goat (occasionally other species). Usually tibiae or metapodials.
2. Epiphysis retained at butt end for grip. Sometimes smoothed from use. Generally distal epiphysis found.
3. Entire circumference of shaft (diaphysis) retained for ca. $\frac{1}{2}$ - $\frac{3}{4}$ length of tool; remainder cut longitudinally toward working end.
4. Lateral edges of working end ca. parallel unlike those of Type 1 which taper. Lower edge (working edge) cut at slight oblique to main axis of shaft producing a fairly broad, flat, working end. Wear usually occurs on underside.
5. Ave. dims: L.0.10-0.14. W.0.015-0.025. Th.(ant.-post) ca. 0.012.

Type 15b: Definition Fig. 83; pls. 80-82.

1. From whole tibiae sheep/goat (one example of pig).
2. Distal epiphysis retained at butt end for grip; sometimes smoothed. Also distal end of bone where epiphysis unfused in juveniles.
3. Entire circumference of shaft (diaphysis) retained for ca. $\frac{3}{4}$ length of tool; remainder cut longitudinally toward working end.
4. Working end of tool formed by natural flare of diaphysis of tibia toward proximal end of bone. Lower edge of tool may be cut at slight oblique to axis of shaft. Very broad, flat working end with wear, generally on underside.
5. Ave. dims. L.0.14-0.18 ca. W.0.025

Type 15a/b: Comment

Apart from the treatment of the working end these implements are comparable to Type 1 pointed tools. They are however rather less frequent.[18] Indeed all blunt types either singly or as a group are less common than pointed implements. This may reflect the range of occupations to which they are suited and also the possible use of other materials, such as stone or shell for activities requiring a blunt tool (see below p. 315).

The principal distribution of the catalogued objects occurs in the EBA. There seems no reason to question this. The Kea example of LBA data comes from a period VI context contaminated with period V (MBA) material.

The Type 15b examples form a distinctive group and occur with at Lerna and Thermi (one item only). Here the working end is not only very broad but also thin in section, ca. 0.002 m, with a roughly semi-circular pattern of wear on the underside.

A number of comparative items can be found in the published material but how close they are to Type 15 is not clear. Many seem to have a very strong bevel on the anterior face where the shaft is cut to form the working end (see pl. 120). Whether this merely reflects different techniques in manufacture, or actually affected the use of the tool cannot be determined at present. However, the shafts of these comparative items do closely resemble the treatment of the comparative examples for Type 1 tools (see fig.124,pl.118 from Lerna neolithic).

Type 16: Definition

1. From whole ulnas of cattle (or possibly deer).
2. Little modification to upper portion of bone or to shaft except at working end.

3. Shaft cut off ca. obliquely to form asymmetrical blunt working end.
4. Dims: L.ca. 0.10-0.15. W. max. ca. 0.03.

Type 16: Comment

Only two examples of this type have been reported from Aegean bronze age contexts although they are known from the neolithic period (see Catalogue). The rarity of ulnas among the worked bone industries of the bronze age has been noted in connection with Type 2 above. It is possible that a change in butchery techniques may account for this.

Type 17: Definition fig. 84; pl. 83.

1. From whole fibulae of pigs.
2. Distal end of bone (epiphysis usually unfused) used as grip; entire length of bone used but with minimal modification.
3. Natural flare toward proximal end used for working end, apparently with little modification.
4. Ave. dims: L. ca. 0.09. W.ca. 0.014. D.shaft 0.005.

Type 17: Comment

Like Type 3 implements made on fibulae of pig, Type 17 is rare. This may be due in part to the availability of the bone (Chapter II) or non-recovery of these items. Indeed there is often so little modification to the bone that it is difficult to be certain whether all the catalogued items were in fact used as tools based on macroscopic examination alone.[19]

Type 18a: Definition Figs. 85-86 pls. 83-84

1. From segments of long bones, either metapodials or tibiae of sheep/goat and cattle.
2. Bone split lengthwise producing rather irregular segment, preserving portion of natural concavity (as Type 5).
3. Little additional modification except at working end. Some items may be broken examples of Type 15 a/b.
4. Working end broad and flat; working edge may be Th. 0.002-0.003. with wear chiefly on underside. Working edge often cut at oblique to main axis of shaft.
5. Dims. vary according to bone used: L.0.06-0.10. W.0.015-0.025.

Type 18b: Definition Figs. 86-87 pl. 85.

1. From segments of long bones, usually metapodials of sheep/goat or cattle.
2. Bone split lengthwise preserving portion of natural concavity.
3. Lateral edges ca. parallel for much of length, working end may be slightly rounded or cut off straight.
4. Working end not flat as in 18b but same thickness as lateral edges of bone. Usually working edge bevelled.
5. Dims. vary according to bone used: L.0.06-0.10. W.0.015-0.025. Th.ca. 0.005-0.008.

Type 18a/b: Comment

Type 18 follows the pattern of other blunt objects in being far less frequent than their pointed equivalents on segments of sheep/goat or cattle long bones. The concentration of this type in the EBA (mainland and N.E. Aegean, only) corresponds to that seen for Type 15 made on whole long bones. Indeed some of the 18a items are almost certainly broken examples of Type 15 a or b.[20]

Type 19: Definition Figs. 88-89 pl. 86

1. From whole rib bones (unsplit), usually cattle or deer (possibly pig).
2. Usually whole bone utilised with proximal end serving as grip. Little modification either here or to shaft of bone.
3. Distal end of rib serves as working end. Often difficult to see whether bone has been modified for this purpose.
4. Working end worn, usually on one surface only, revealing cancellous material inside.
5. Ave. dims: L. 0.15-0.20. W. ca. 0.025.

Type 19: Comment

The similarity of this type to unworked bone is probably reflected in the scarcity of this type. Apart from a single example from Thermi all catalogued items come from Lerna.[21] It is not clear whether any were worked prior to use. They occur with Type 20 in Lerna IV contexts (see also below p. 276).

Type 20: Definition Figs. 90-91 pl. 87.

1. From portions of unsplit ribs of cattle (also deer and pig).
2. Some examples with neatly cut butt ends from near proximal end of bone; others may be broken examples Type 19.
3. No apparent modification to shaft or to bone at distal end which forms working end of tool.
4. Broad working end, worn on one surface revealing cancellous material.
5. Ave. dims: L. ca. 0.10-0.15. W. 0.025-0.03

Type 20: Comment

All catalogued items are from Lerna IV contexts (also below p. 276).[22] The problems of recovery for this type are similar to those mentioned above Type 19 but parallels do exist from Saliagos indicating that careful attention to worked bone both in excavation and by publication of good drawings may improve our chances of locating parallels in published material. Possible comparisons for this type may also exist in Thessaly.

Type 21: Definition Fig. 92; pl. 88.

1. From portions of ribs of cattle (also pig and possibly deer).
2. Bone split lengthwise, leaving cancellous material on underside. Some examples carefully cut and resemble Type 12 implements apart from their sharp tips, with cancellous material smoothed especially around lateral edges and working end. Others may be broken examples of Type 19, 20.
3. Lateral edges taper gradually to rounded working end, sometimes slightly bevelled.
4. Ave. dims: L.0.07-0.10. W.0.015-0.02. Th.ca.0.003.

Type 21: Comment

Apart from the four items from the North-east Aegean (Emborio and Thermi) all examples come from Lerna (III and IV).[23] Some of these are almost certainly broken examples of 19 or 20 characterised by rather rough appearance and unsmoothed cancellous material on the underside. The isolation of this type in published material is exceptionally difficult since it is rarely possible to tell from photographs where the wear occurs on objects. Consequently, a number of items included in Type 30 (Bladed-objects) defined as having wear principally on one lateral edge could, given first-hand examination, be re-classified here.

Type 22: Definition Figs. 93-94; pl. 89.

1. From portions of deer antler tine (usually Cervus elaphus).
2. Tine not split and usually little modified. Butt end may be cut off straight, although not always.
3. Distal end of tine serves as working end with no modification. Working end round and blunt or slightly bevelled.
4. Ave. dims: L.0.05-0.10 (but may be up to L.0.30). D. 0.015-0.025.

Type 22: Comment

Apart from the Thermi examples and that from the forthcoming publication of Emborio all catalogued items are from unpublished collections.[24] It is however possible that some of the worked 'horn' from Malthi may be tines but the photographs are too small and of poor quality to tell. The similarity of Type 22 objects to unworked, or partially worked antler is such that they may have been overlooked in excavations not employing a faunal analyst. Even among the tines which have been isolated as 'worked bone' it is frequently impossible to determine whether the smoothing toward the distal end is natural or the result of human activity (see above p. 143 and also below Type 72: partially worked antler).

Type 23: Definition Fig. 94; pl. 91c

1. From large portions of antler tines (unsplit) or segments of main beam.

2. Rough, rather heavy implements with very little additional modification except at working end.
3. Working end cut off roughly at oblique angle to main axis of shaft producing broad, flat working surface.
4. Ave. Dims: L.0.10-0.15. D.ca.0.03.

Type 23: Comment

There is little resemblance between the items included under this type apart from a general similarity in method of manufacture, namely cutting the distal portion of the tool into a broad, irregular working end at an oblique angle to the shaft. The Malthi example is not certain owing to poor quality of the photographs while general recovery of such items might be due to their rough appearance and lack of specialist identification of worked bone and antler in older excavations.

Type 24: Definition Fig. 95; p. 90.

1. From broad segments cattle long bones or antler main beam.
2. Material quite carefully worked with straight lateral edges usually flaring out slightly toward working end. ('Celt-shaped').
3. Working end usually cut at right-angles to main axis of shaft and slightly bevelled from upper surface which is worn smooth. Small portion underside may also be smooth around working edge only.
4. Ave. dims: L.0.07-0.10. W.0.02-0.025.

Type 24: Comment

The general scarcity of blunt implements may account in part for the distribution of this type in the catalogue although it should be noted that all but two items come from Ayia Irini and Lerna.[25] It is also interesting that Ayia Irini provides us with two items of LBA data (and three as yet unphased) since most blunt objects of whatever shape and material are known from EBA contexts. The Kea evidence may support the theory that our LBA evidence is unbalanced owing to the preponderance of palatial rather than settlement material excavated and published.

<u>Type 25: Definition</u> Fig. 96; pl. 91a.

1. From segments of long bones, probably cattle; or portions of antler main beam.
2. Lateral edges parallel and carefully worked tapering very slightly toward working end. Flat and sub-rectangular in section; all traces of natural concavity removed in bone examples.
3. Working end rounded and bevelled from both sides producing a chisel-like working end.
4. Ave. dims: L.<u>ca</u>. 0.08-0.10 W.0.015-0.02.

<u>Type 25: Comment</u>

As may be expected from a type consisting of so few examples it does not produce a very homogeneous appearance. The presence of these blunt objects from antler at the Citadel House, Mycenae which also produced a number of Type 13 pointed tools on antler may be noted.

<u>Type 26: Definition</u> Fig. 96; pl. 91b-c.

1. From very heavy segment of cattle long bone or antler main beam or tine. <u>Ca</u>. round in section.

2. Apart from initial cutting of segment, very little further modification; may taper slightly to working end.
3. Broad, blunt working end cut at rough oblique to main axis of bone.
4. Ave. dims: L.0.10-0.15 W.ca.0.03.

Type 26: Comment

There is only a general similarity between objects in this type. The possible parallels of 'horn hammers' and 'pick-axes' from Thessaly may be noted although without first-hand examination it is difficult to determine how accurate the comparison is.

Type 27 ('Spoons'): Definition Figs. 9d, 97.

1. From various materials, bone, antler and ivory.
2. Segment of material fashioned into a spoon-like object with round or rectangular 'bowl' and cylindrical handle.
3. Ave. dims: 'Bowl' ca. 0.03 x 0.02 Th.ca. 0.005 D.handle ca. 0.003.

Type 27: Comment

These spoon-like objects are characterised by very fine working of the material. Apart from the Kea example all come from Mycenaean contexts on the mainland. The use of antler for 27: 1 from Kea is especially interesting as is the period V date, Fragments of spoon-like objects were also discovered among the Evans' Unknown Provenance material (see Appendix IIa).

Type 28: ('Cosmetic spatulae'): Definition Fig. 97 c.pl. IX.

1. From segments of long bone or ivory.
2. Material worked to a cylindrical pin-like shaft.

3. 'Butt end' may be rounded or slightly pointed like top of a pin; 'working end' may be rounded or slightly pointed like tip of a pin; 'working end' flat and bevelled from both sides like a spatula.

4. Ave. dims: L. <u>ca</u>. 0.08-0.10 D.<u>ca</u>. 0.005.

<u>Type 28: Comment</u>

Of the six catalogued items, four are very closely related (28: 2,4,5,6). Three of them are from the Citadel House, but the fourth comes from Thebes. It is curious that no others have been recovered from Mycenaean sites, although if broken they would of course resemble pins (11e: undiagnostic). The example from Argos-Deiras is placed here tentatively for although it does not look like the main examples of this type it seems to end in a flattened oval or spatulate element. The same may be true of the Citadel House example (28: 3) carved from ivory in the shape of an arm. This item is unique and was found in the Pot Group (see below). It might not be of Mycenaean manufacture.

<u>Type 29: Unclassified blunt objects</u> Fig. 98; pl. 92.

As discussed above (Type 14: Unclassified pointed objects) a number of tools exist which cannot be grouped in any of the established types. This occurs in the case of blunt objects as well. There is a relatively small number of these items reflecting the relative quantities of pointed and blunt implements. In publications they can sometimes be identified by their description as 'polishing implements' or 'spatulae'. It should be noted that in the published material there are tools which cannot even be divided between pointed and blunt owing to inadequate descriptions and poor photographs.

GROUP III: BLADED AND SERRATED OBJECTS

This small group consists of types which are characterised by a blade-like appearance with wear chiefly on the lateral edge. This wear rarely occurs for the whole length of the lateral edge but is confined to the part of the tool furthest from the hand or butt end. Serrated objects may have teeth along one or both of their lateral edges. All items in these types are very thin and flat, generally made from split rib bones.

Type 30a: Definition Fig. 99, pl. 93

1. From flat portions of bone, usually split ribs of cattle (possibly deer).
2. Butt end cut off straight with lateral edges tapering gradually to rounded point.
4. Ave. dims: L.0.06-0.08. W.ca.0.02. Th.ca.0.003.

Type 30b: Definition Fig. 99.

As sub-type a but pierced near butt end.

Type 30a/b: Comment

The principal distribution of this type is the North-east Aegean in the EBA. The difficulties of differentiating between this type and Type 21 (Blunt objects on split ribs) when working from photographs has been noted above. Apart from the perforation at the butt end there seems no appreciable difference between the sub-types 30a and b. They are closely related to the following type (Type 31). All have a general resemblance to modern paper knives.

Type 31a: Definition Fig. 99, pl. 93.

1. From flat portions of bones, probably split ribs in all cases.
2. Butt end has rudimentary articulation from shaft, either a slight narrowing to form 'neck' or is notched. May be pierced.
3. Lateral edges ca. parallel for much of length then taper slightly to form rounded point. Wear along lateral edge near pointed end.
4. Ave. dims: L.0.06-0.10. W.ca.0.015-0.02. Th.ca.0.003.

Type 31b: Definition

As sub-type a but butt end characterised by distinct articulation between 'head' and rest of tool by narrow 'neck'. 'Head' often pierced and round in plan.

Type 31a/b: Comment

Apart from the treatment of the butt end, there seems little significant difference between this and the preceding type. The purpose of the articulation between head and shaft is not clear, while the 'idol-headed' (sub-type b) examples from Poliochni alone may simply reflect a local 'fashion'. Apart from two mainland items and a comparative piece from Kritsana all examples come from the North-east Aegean.

Type 32a: Definition Fig. 100, pl. 94.

1. From split rib bones of cattle or deer.
2. Segment of bone carefully worked and all traces cancellous material removed from underside, producing an extremely thin (Th. 0.001-0.002) implement. Butt end cut off straight.

3. One or both lateral edges serrated with more or less regular teeth L.0.001-0.002.
4. Ave. dims: L.0.07-0.10. W.ca.0.015. Th.0.001-0.002.

Type 32b: Definition Fig.100, pl.94.

As sub-type a but with butt end articulated from rest of tool by narrowing at 'neck' or by notches similar to some type 31 items.

Type 32a/b: Comment

Only two examples of this type are known from the North-east Aegean (Emborio); all others are from either Ayia Irini or Lerna.[27] These tools are very fragile owing to their thin sections, although they would probably have been more resilient and even slightly flexible when the bone was fresh. The butt ends of some (especially sub-type b) suggest that they may have been inserted into a handle to facilitate use. (above p. 184).

GROUP IV: TOOTHED (DENTICULATED) OBJECTS

This group consists of only two types which may be termed 'combs'. The first includes rather rough objects of bone or antler with rather short blunt teeth; the second (Type 34) includes the fine combs which are generally made from ivory. 'Haircombs' ('Peignes de coiffure') are found under Type 70: Miscellaneous ivory objects.

Type 33: Definition Fig.101, pl.95.

1. From portions of cattle ribs (unsplit) or segments antler main beam.
2. Usually only roughly shaped with teeth along one lateral edge.

3. Teeth irregular and shallow (L.0.002-0.003) generally smooth and worn thin at the edges; other lateral edge may also be smooth.
4. No examples certainly preserved intact. L.pres. ca. 0.08-0.10 W.0.02-0.04 Th.0.005.

Type 33: Comment

Apart from a single example from Mallia, not certainly of this type, all items are from mainland contexts.[28] The Krisa examples, are also rather different from the main examples of this type. With so few pieces from differing contexts it is impossible to make observations about the role of these objects in the worked bone industries.

Type 34 (Fine combs): Definition pls. 25a, 96.

1. From ivory. (Bone might also be used although no definite examples have been identified by myself).
2. Shape may be either square or rectangular (also see below sub-type c). Slightly tapering in section with greatest thickness at top of 'handle' or 'back'.
3. Treatment of handle varies (see below). Lower portion of object cut with fine, slightly tapering teeth.
4. Ave. dim: L.0.06-0.10 H.0.03-0.05 Th.0.005-0.015.

Sub-types

a) Handle not decorated. Usually divided into registers and sometimes having central rosette in low relief.
b) Handle decorated with low relief carving (e.g. animals, lizards, sphinxes). Central rosette and registers.

c) Elongated handle projected at one side of the comb. Decorated. Poursat type A: 'Peignes à corne'.

d) Combs mentioned in the literature without illustration or full description and which therefore cannot be classified.

Type 34: Comment

The majority of catalogued items come from Mycenaean contexts on the mainland of LMIII contexts on Crete. For the date and significance of the Palaikastro comb (34b: 12) see further pp. 302 and 311 f. The undecorated comb from Ayia Irini is discussed below p. 280.

Fine ivory combs are fully discussed by Poursat in Iv. Myc. pp. 22-25.

GROUP V: TUBES, HANDLES, GRIPS

This large group consists of types have very different appearance and are made from bone, antler and ivory. Apart from 'Tubes' (Type 35) which present difficulties in interpretation, the other types all seem linked to the purpose of providing handles for objects in other materials. Sometimes the evidence of this function is direct, such as the preservation of bronze awls in handles made from long bones (Type 37) or swords with ivory pommels (Type 43) still attached. In other cases the purpose is less clear but indications exist that the type was somehow attached to other objects possibly to facilitate handling, although definite proof is lacking (see Type 40, 41).

Type 35 (Tubes): Definition Figs. 101-02 pl. 97.

1. From long bones, especially metapodials and tibiae. Various species: especially sheep/goat, also hare and cattle.

2. Both epiphyses removed, full circumference of bone retained, forming hollow cylinder. Sometimes perforated.
3. Dims. vary according to bone used; a and b only - L.ca. 0.05-0.10 D.0.006-0.012.

Sub-types

a) Plain tubes, undecorated. Shaft may be polished.
b) Tubes decorated with incision, especially herring-bone or hatched triangles.
c) Short hollow cylinders of long bones or antler; little modified. L.ca. 0.03 D.ca. 0.02.

Type 35: Comment

Although included in this group there is no direct evidence to suggest that these objects were used as handles, although sometimes they may be referred to such in the literature. Most examples are of EBA date in all areas but Crete. Few decorated examples (35b) are known outside the Cyclades. Those from Corinth and Krisa (35b: 4,5) have rudimentary decoration in comparison with the Cycladic examples while the single decorated piece from Poliochni is so close to the main sequence as to suggest a direct import. The precise purpose for the long tubes made on sheep/goat tibiae from EHII Lerna cannot be determined, although the grooves at each end have been linked to 'thread marks'.[29] They may be paralleled by 35a: 12 from Eutresis. The use of the Cycladic pieces as paint or pigment holders may be noted suggested by the traces of colouring material and 'stoppers' (see under 35b: 3 and 10).

Type 36: Definition

1. From rough, irregular segment of antler main beam.
2. Very little modification apart from preliminary cutting and boring of large hole in centre of beam.
3. Dims. vary.

Type 36: Comment pl. 9.

The identification of this type for the Aegean bronze age is tentative and rests on several pieces from Ayia Irini and Lerna. There are similarities between these and antler handles 'horn club handles' from Thessaly (see above p. 141 and Catalogue). However, since we have no independant evidence for their use, they could equally be considered under our category of partially worked antler (Type 72).

Type 37a ('Handles'): Definition Figs 104-05 Pls 13a, 98

1. From long bones, usually metapodials or tibiae of sheep/ goat (also hare and pig).
2. One epiphysis retained as grip, other end of bone cut off. Ca. ½ length of diaphysis of bone preserved.
3. Cut end may or may not be further trimmed before insertion of implement in other material. At present evidence only exists for insertion of bronze tools into handles but stone also possible.
4. Ave. dims: L.0.06-0.08 (with bronze implement: L.0.10-0.14). W.0.015-0.025.

Type 37b ('Handles'): Definition

1. From portions of deer antler tine.

2. Whole circumference of tine preserved; cut through transversely toward distal end.
3. Cancellous interior of tine slightly hollowed out at distal end for insertion of bronze implement.
4. Ave. dims: L.*ca*.0.06-0.10 D.max. *ca*. 0.02.

Type 37a/b: Comment

The identification of this type and its use as handles or grips rests on a number of instances where a bronze implement usually pointed and referred to as 'awl' is preserved *in situ*. Only one implement is so preserved in an antler handle (37b: 7) from Tiryns but the bone examples are rather more numerous. Other items (including the antler handle from the Citadel House) have traces of bronze or staining which strongly suggests that they were indeed used as handles from a tool now lost. Many of the catalogued items are included here simply on the grounds of morphological similarity to the pieces with bronze tools preserved. That is, there is no direct evidence for their use as handles but their shape suggests that they could have been so employed. This is especially true for items which have been carefully cut and trimmed. Pieces with a broken shaft are included here only tentatively. A number of good parallels for this type both in bone and antler occur at Troy (see Catalogue). The lack of examples from MH contexts on the mainland may be fortuitous.[30]

Type 38 ('Knife handles'): Definition Fig. 105.

1. From ivory or possibly segments of long bone.
2. Usually two symmetrical pieces rounded at the butt end. Between the pieces is inserted the tang of a bronze knife held in position by two or three bronze rivets.

3. L.handle _ca_. 0.07 W._ca_. 0.015.

Type 38: Comment

Only a small number of items exists but it is difficult to determine whether the use of bone and ivory for such objects was in fact rare (with ? wood being more common) or whether much of our material has perished. Certainly there do exist other bronze knives with tiny traces of bone or ivory, usually adhering around the rivets and which have not been included in this catalogue. All catalogued examples are from LBA contexts.

Type 39 ('Hilt-plates'): Definition

1. From thin pieces of ivory or possibly bone.
2. Pieces cut to the shape of the hilts of a sword and attached by means of rivets.
3. Dims: Difficult to ascertain owing to fragmentary condition of examples.

Type 39: Comment

Difficulties similar to those mentioned above Type 38 occur in the identification of 'Hilt-plates' as a distinct type. It seems that they were more commonly made from perishable materials including wood.

Type 40a: Definition

1. Flat disc-like objects with central piercing, made from ivory. May be decorated with incision.
2. D. 0.04-0.05 D. hole. _ca_. 0.015-0.02.

Type 40b: Definition

1. From flat pieces of ivory cut to lozenge-shape.
2. Rectangular perforation in centre; edges may be bevelled.
3. Ave. dim: L. 0.10-0.14 W. 0.05-0.06 Th. 0.01-0.015.
   Central openings: 0.05-0.06 x 0.01-0.015.

Type 40a/b: Comment

These items are classed together in the same type despite rather different appearance as they are thought to be connected with guards for sword handles and pommels. The catalogued items were not, to my knowledge, found attached to swords and the interpretation of their function is not wholly certain. Type 40a is discussed by Poursat in Iv. Myc. under the heading 'rondelles de pommeau'. (pp. 35-36). Type 40b items have been interpreted as 'pièces de fourreau' ('hilt-guards') by Poursat (Iv. Myc. pp. 36) and as the tops of scabbards by Symeonoglou who provides reconstructed drawings (Kadmeia I, fig. 248-49). All examples come from Mycenaean contexts on the mainland.

Type 41: Definition fig 107; pl. 116a

1. From ivory or possibly heavy segment of long bone.
2. Roughly mushroom-shaped upper portion with long 'stem'. 'Stem' may have raised central ridge and has two or three perforations (rivet holes).
3. Underside ca. flat and less carefully finished.
4. Ave. dims: L.0.06-0.07 W.0.025-0.02 Th.ca.0.01-0.015.

Type 41: Comment

These items are included in this group of handles and related objects with certain reservations. It seems clear from the rivet holes that these pieces were intended to be attached to objects in other materials but their exact purpose has been debated. The two principal interpretations are that these served as hilts (or handles) for swords or knives; or were attachments for lyres. In the second case they are reconstructed as occuring on the ends of the cross-piece of the lyres. Unfortunately apart from the Menidi example none have been found in association with other pieces of ivory which would have formed the 'arms' of the lyre. It is of course possible that those were made from wood with only portions added in ivory. See also discussion in Iv. Myc. p. 37.

Type 42a: ('Knobs'): Definition Fig. 107 pl. 116b

1. From ivory or antler
2. Small semi-spherical knob-shaped objects. May be pierced through vertical axis or provided with mortise at base only.
3. Very short neck.
4. Ave. dims: H.ca. 0.02 D.0.02-0.03.

Type 42b: Definition

1. From ivory or antler.
2. Semi-spherical knob on top of long cylindrical neck.
3. May be decorated with incision.

Type 42a/b:- Comment

There is no independent evidence for how these items were used although they seem to fit well in the general group of handles and related objects. Some like that from the Citadel House, Mycenae are really miniature versions of pommels, in shape if not in function. The examples published as 'bone' from Asea and Zygouries are almost certainly made from antler tine. It is difficult to see how they could be made from true bone. The similarity between the Kakovatos item (42b: 1) and that from Zygouries (42b: 3) is striking, but surely coincidental given the large time gap.

<u>Type 43 ('Pommels'): Definition</u> Fig. 107, pls. 33, 37.

1. Ivory (but see comment).
2. Semi-spherical or sometimes flattened dome-shaped. In plan usually circular although slightly oval items also known.
3. Usually provided with short 'neck' on underside in which is cut a square, or less often, circular, mortise for attachment to bronze weapon (sword, dagger, knife). Rivet holes in sides of mortise cutting.
4. Ave. dims: D.<u>ca</u>. 0.05-0.07 H. 0.003-0.05.

<u>Type 43: Comment</u>

Apart from the curious example from Mallia described as being made from the proximal epiphysis of the humerus of <u>Bos primigenius</u> all catalogued items are made from ivory. Other objects made from the proximal epiphysis of cattle femur exist and are sometimes called 'pommels' but there is nothing to relate them to the ivory objects of Type 43 known to have been used as pommels for swords. These bone objects are catalogued separately under Type 46 (see also Type 48).

A number of our examples of Type 43 items are still attached to their swords and have been found chiefly in LBA burial contexts.

These pommels are one of the earliest uses of ivory on the mainland at the time of the shaft graves (see also below p. 308). Their occurrence on Crete is less well-attested. Whether the prepalatial examples described as 'pommels' from Platanos properly belong to this type is not certain. They may in fact be closer to our Type 42 'Knobs'.

Type 44 (Mirror-handles): Definition

1. From large pieces of ivory.
2. Cylindrical or octagonal grip end and rectangular or circular plaques into which the bronze mirror is inserted and held in position by means of two or three bronze rivets.
3. Decoration in relief.
4. Ave. dims: Total L. (H.) 0.12-0.17 W. handle ca. 0.02 W. plaque ca. 0.05-0.07.

Type 44: Comment

All examples come from Mycenaean sites on the mainland apart from four found in LMIII contexts.[31] All have been recovered from burials. A full discussion of this type, both form and decoration may be found in Poursat, Iv. Myc. pp. 18-21.

Type 45: Miscellaneous handles and related objects

Under this heading are catalogued a number of objects variously described in publications as 'handles', 'pommels' and 'grips'. In some cases no illustrations are provided making it impossible to place them in any of the previous categories. Others have no close parallels. Examples occur in both bone and ivory.

GROUP VI: HEMI-SPHERICAL AND DISC-SHAPED OBJECTS

This group includes objects of both bone and ivory which are either hemi-spherical or slightly convex discs often pierced in the centre. Their purpose can rarely be determined but many are described as 'pommels', 'weights', 'whorls' and 'buttons'.

Type 46a: Definition Fig 108, pls. 6, 116c

1. From proximal epiphysis of cattle femur cut off transversely. Producing a hemi-spherical object.
2. Bone perforated through vertical axis. Very little additional modification.
3. Ave. dims: D. 0.04-0.05 H. 0.015-0.02.

Sub-type b

As a) but smaller, possibly from sheep/goat although not verified D. ca. 0.02 H. ca 0.008.

Type 46a/b: Comment

As indicated above (p. 248) there is nothing to link these items with the true ivory pommels of swords (Type 43). The similarity in appearance is also quite superficial and none of the Type 46 items are provided with 'neck' or mortise which would serve for attachment to a weapon. The diameter of the hole is about 0.005 m. For their possible use as loom-weights see Chapter II p. 18 and n. 21. With the exception of one example from a Lerna V context all catalogued items are from EBA contexts.[32] For parallels from the unknown provenance material from Tiryns see Appendix IIb.

Type 47: Definition Fig. 109

1. From ivory.
2. Small objects with flat underside and convex upper surface; some nearly hemi-spherical; others only very slightly rounded.
3. Some with central holes; others with means of attachment from underside.
4. Ave. dims: D. ca. 0.025 Th. 0.08-0.02.

Type 47: Comment

The appearance of these objects varies considerably yet are all sufficiently close to be grouped together. In the case of many small objects which may have had a principally decorative function there is far less uniformity in appearance than found within more utilitarian types (see also Type 51). The purpose of these objects is not clear although they are generally described as 'buttons' or even 'beads' in the literature. They may be related to items placed under Type 49 and also Type 51 (Miscellaneous 'buttons and beads'). Apart from a tentative example from pre-palatial Crete all items come from LBA contexts.

Type 48: Definition Fig. 108, pl. 6.

1. From os magnum of cattle or transverse section of proximal epiphysis of cattle femur.
2. Large, disc-like objects, pierced vertically. Carefully cut but given no additional polishing (cf. Type 49).
3. Ave. dims: D. 0.03-0.04 Th. ca. 0.01-0.015.

Type 48: Comment

These objects seem to be related to Type 46, made from similar bones and occurring on the same sites (Lerna, Poliochni, Zygouries) chiefly during the EBA.[33] Although termed 'pommels' or 'whorls' in the literature there is no definite evidence for their function.

Type 49: Definition pl. 25c

1. From ivory or bone.
2. Disc-shaped, usually rather flat but some examples slightly convex. Pierced in the centre.
3. Ave. dims: D. 0.025-0.02 Th.0.005-0.01.

Sub-types

a) Undecorated examples.

b) Decorated with incision, usually spiraliform motifs, also circles with central dots.

Type 49: Comment

The undecorated examples do not seem to have a very uniform appearance apart from the Perati group although it is difficult to determine such matters when isolating a type from published material alone. Some may in fact be closer to objects in Type 47. Sub-type b is based principally on the bone 'buttons' from Shaft Graves IV and V covered in gold-leaf and similar objects of both bone and ivory from Kakovatos. None of these has been handled by myself so it is impossible to verify the identification of material. If bone was indeed used, and that may seem reasonable for objects to be covered in gold leaf, then they may have been cut from scapulae of cattle.[34] The Kea example of sub-type b is more fully discussed below (p. 281). Here it may be noted that the decoration is almost identical to mainland examples and may be an import rather than local copy. The material is ivory.

GROUP VII: TOGGLES, MISCELLANEOUS BEADS OR BUTTONS, PIERCED TEETH AND SHELLS, HELMET PLAQUES, AMULETS, SEALS.

The types included in this group do not resemble each other closely but there is some justification in bringing them together under a general heading. Almost all the individual items are provided with perforations or string-holes. In the case of objects known as toggles and small items considered to be 'beads or buttons', these may have permitted attachment to cloth or leather. Pierced teeth or shells may have been threaded onto necklaces and amulets and many seals are also provided with string-holes. Finally helmet plaques are known to have been sewn onto a backing to make boar's tusk helmets.

Type 50: (Toggles): Definition Fig. 110, pl. 99

1. From slender, heavily worked segments of long bone or ivory.
2. Usually approximately cylindrical pieces provided with indentation or groove at mid-point. Not perforated.
3. Ave. dims: L.0.03-0.05 D.*ca*. 0.007.

Type 50b: Definition Fig. 110, pl. 99.

1. From heavily worked segments of long bone.
2. Approximately cylindrical at mid-point; perforated.
3. From maximum diameter at mid-point shaft tapers toward each end. Ends provided with nail-like heads, *ca*. same diameter as that at mid-point.
4. Ave. dim: L.0.06-0.07 D.0.006-0.008:

Type 50a/b: Comment

The objects in this group are all finely worked, especially those from Lerna (period IV, V) which are the only examples of sub-type b.[35] The Mycenaean examples (50a: 7-9) called 'pièce d'attache' by Poursat (<u>Iv. Myc</u>. p. 38) are included here tentatively. All catalogued items come from the mainland.

<u>Type 51: Miscellaneous Beads and Buttons</u> Fig 109

There are a number of objects found in the literature under the name of 'beads or buttons' but which cannot be related to any of the types set forth in this catalogue. Occasionally several similar items may exist but for many no parallels are evident. It would appear that for the most part bone and ivory were not generally employed for bead manufacture during the Aegean bronze age, and other materials such as stone or paste more common. This is certainly the impression gained by studying the bone and ivory corpus and appears to be confirmed from the standpoint of jewellery.[36]

<u>Type 52: Pierced shells and teeth</u> Fig. 111, pl. 100

Pierced shells and teeth of small animals are known from a number of Aegean sites in the bronze age. It may be supposed that they were worn as a form of ornament, perhaps strung together as a necklace. The best example of such a necklace is found in the comparative material from Macedonia, where some 31 pieces including dog's (?wolf's) teeth, grooved beads of bone and cat's claws were recovered in a small pot at Ayios Mamas.[37] Occasionally bones of small animals seem to have been used as the fox metapodials at Lerna (Chapter II, p. 23 and n. 27). In this category may also be placed unworked vertebrae of fish (see pl.100).

Type 53: Boar's tusk helmet plaques

1. Small segments cut from the tusks (lower canines) of wild boar.
2. Shapes vary somewhat according to intended position on the helmet: may be rectangular with holes in each corner; quadrangular with holes bored from underside to lateral edges; or nearly square with holes through centre.
3. Outer enamel of tusk preserved on upper surface of plaque.
4. Dims. vary: L.ca. 0.02-0.06 W. 0.02-0.03 Th.ca. 0.002-0.003. D. holes ca. 0.001.

Type 53: Comment Pls. 14-15.

Helmet plaques and the hunting of wild boar are discussed in Chapter II (p. 31ff). The earliest plaques seem to be those from House E at Eutresis (Chapter II n. 43) and the boar's tusk helmet appears to be a mainland rather than Cretan form. A fine example of a helmet is however known from the LMIII burials at Zapher Papoura. The discovery of plaques, almost certainly from a helmet at House A at Ayia Irini should also be noted (see further below p. 281). The context is Kea VII (LMIb/LHII).

Type 54 ('Amulets'): Definition

1. From small segments of ivory (although portions of long bone might also be possible).
2. Rather flat; carved in the shape of small animals or birds. Perforated, usually through head or back of animal.
3. Dims: L. (H.) 0.03-0.04 W. ca. 0.02 Th. (?) ca. 0.01.

Type 54: Comment

All items come from pre-palatial burials on Crete. Although described as 'amulets' we cannot be certain that they were endowed with any special powers and may simply have been a form of adornment.

Type 55: Cretan seals pls. 4, 29, 30, 34b, 38, 37a, c; C. pls. VII, VIII, IX.

1. From bone, boar's tusk or ivory.
2. Small segments carved into various shapes and provided with one or more flat surfaces decorated with incision and serving as 'seal faces'.
3. Many provided with suspension holes, either singly or meeting in the form of a Delta.
4. Dims. vary: H. 0.01-0.04 D. 0.01-0.03.

Type 55: Comment

Those aspects of Cretan seals relevant to this study are considered in Chapter III and a full catalogue of the bone and ivory seals from Lebena is presented as Appendix III. Since seals have been so well published in the volumes of CMS and discussed from many standpoints they are given only cursory treatment in the Catalogue. All seals are included under this single type. They are presented in groups according to the shape in which they are carved: e.g. hammer-headed, cylinders, cones and are simply listed by site, Iraklion inventory and CMS numbers. A full explanation of presentation is given on the introductory pages to this type in the Catalogue.

GROUP VIII: INLAYS AND ATTACHMENTS (Types 56-61).

This group consists of a large number of items which range from very small plain inlays (D. 0.01) to rather large attachments carved partly in the round (e.g. figure-of-eight shields). All are characterised by the fact that they seem to have formed part of larger compositions often in conjunction with other materials. Although few of the pieces offer direct evidence for their precise use, the presence of scoring, mortises, rivet holes or even bronze and ivory pegs indicate that they would have been attached to other materials, whether boxes or pieces of furniture. Since many of these items are from Mycenaean contexts and have been fully described by Poursat in his Catalogue a fairly cursory treatment is adopted here.

Type 56: (Plain inlays): Definition Figs. 112-119 Pl. 101.

1. From ivory or bone (probably segments of long bones).
2. Flat pieces cut into various geometrical shapes. Undecorated.
3. Underside usually scored to facilitate attachment (? and use of adhesive). Sometimes provided with holes; bronze and ivory pegs attested.
4. Dims. vary: see Catalogue.

Sub-types

Eight principal sub-types may be isolated: squares, plano-convex, strips, triangles, lozenges, rectangles, dog-tooth (stepped) and discs. See individual pages in Catalogue for more complete descriptions.

Type 56: Comment

Small inlays of bone occur on Crete during the first palace period and continue in bone and ivory through the second palace period. They constitute the majority of finds from the LMIb Ivory Deposit on the Royal Road. Although there the shapes are confined to squares, plano-convex inlays and strips they are of a very high degree of workmanship and show considerable precision in manufacture (see Chapter IV). Small inlays occur widely during the Mycenaean period although the range of shapes is slightly different. Plano-convex items do not seem to have been used, nor are squares very common. In the Cyclades only Ayia Irini has, to date, yielded any Type 56 objects (one plano-convex and two small discs).

Type 57 (Inlays with incised decoration): Definition

1. Ivory or segments of bone (probably long bones, although rib also possible).
2. Pieces cut to simple geometrical shapes and provided with decoration in incision.
3. Motifs generally simple: circles with central dot or concentric circles joined.
4. Dims. vary according to sub-type see Catalogue.

Sub-types

a) Strips: usually narrow (ca. 0.01-0.02).
b) Discs: with centre-point and incision around periphery; otherwise similar to Type 56h.
c) Rectangles and squares with various motifs.

Type 57: Comment

Apart from a handful of objects from the EBA and MBA these items are all from Mycenaean contexts on the mainland. The early examples are quite interesting if only for their rarity - while that from an MH context from Thebes made from ivory is of considerable importance (see p. 49 and 307). The discs of the Mycenaean period occur in great quantities and are related to the cut-out inlays presented under Type 58.

Type 58: (Cut-out inlays): Definition p. 102

1. From flat pieces of ivory. (No examples known in bone although the shape and size would be possible).
2. Cut-out shapes with incised internal details.
3. Not perforated but may be scored on underside to facilitate attachment.
4. Dims. vary according to shape: See Catalogue.

Sub-types

A wide variety of shapes conforming to this type is known including the familiar rosettes and waz-lilies. For a list of the forms see the introductory pages to Type 58 in the Catalogue.

Type 58: Comment

The motifs on which the cut-out inlays are based are considered fully by Poursat in his section on 'Motifs ornamentaux' in Iv. Myc. p. 94 ff. although it should be noted that his lists include the use of these motifs in other compositions as well. For example under his heading of nautili one will find not only the cut-out inlays but also the use of that motif in relief carving or incised plaques (Type 57). However since virtually all the cut-out inlays are found in Poursat's Catalogue of the Athens National Museum ivories, they are not repeated in catalogue form here. They are merely listed according to shape, Athens inventory and Poursat catalogue in the manner adopted for Cretan seals. Thus, the lists should provide in easy reference to those sites yielding cut-out inlays of particular shapes. Where the item does not occur in the ANM catalogue, standard entries are provided.

Type 59 (Grooved inlays): Definition fig. 120, pl. 103

1. From ivory or segments of long bone; shell and boar's tusk also reported.
2. Small pieces of geometrical shapes, usually strips, squares or rectangles decorated by series of grooves.
3. Section plano-convex (sometimes called hemi-spherical), or flat. See also comment.
4. Dims. vary: see Catalogue.

Type 59: Comment

It is sometimes difficult to distinguish between items decorated with deep incisions and those which are truly grooved or segmented, when working from published sources. As with plain inlays (Type 56) these objects first appear in first palace period contexts on Crete. At Mallia they occur in bone and shell (see also below p. 299). During the LBA they occur principally in Mycenaean sites on the mainland. The largest deposit is that from the Kadmeia at Thebes where considerable variety in the sections of these inlays may be noted.[38]

Type 60 (Inlays with relief decoration): Definition

1. From pieces of ivory.
2. Flat segments carved in the shape of rosettes or waz-lilies with internal details rendered in low relief.
3. Dims. vary considerably but examples usually larger than cut-out inlays.

Type 60: Comment

The motifs are found in Poursat's lists in Iv. Myc. pp. 108 ff and 119 ff. Most examples are found in his Catalogue with full description therefore only a cursory treatment is adopted here with items listed by site and inventory number.

Type 61 (Attachments in relief): Definition Fig. 120 pls. 102, 104-06.

1. Usually from ivory.
2. Pieces carved into a variety of shapes, partly in the round. Flat underside and mortises or other means of attachment on underside.
3. Internal details (if any) may be rendered in low relief.
4. Dims. vary according to shapes.

Type 61: Comment

Attachments in relief are first attested in the second palace period on Crete although the number of examples are not large. Shapes include double-axes and sacral knots; some such as the Zakro butterfly are unique. The carving is of high standard. The use of attachments in relief becomes widespread during the Mycenaean period when a variety of standard shapes emerges. The most common are the figure-of-eight shield plaques and columns. Other forms include warrior heads, and shells. These occur chiefly on Mycenaean sites on the mainland but are also found in contemporary Cretan contexts.

Since most of the motifs and individual items have been dealt with by Poursat, most are only listed here by site and inventory number. In cases where the objects are not in the ANM standard catalogue entries are given. In addition there is a number of catalogued items from Mycenaean sites which do not conform to the principal shapes considered by Poursat; these too are catalogued under Type 61: Miscellaneous examples.

GROUP IX: VARIOUS OBJECTS: (All materials)

This group includes types which are not related to others included in the catalogue as well as miscellaneous objects in the four materials under consideration in this study.

Type 62: Ornamental plaques

This type consists chiefly of large plaques of ivory with carved decoration in low relief (sub-type b) although some are decorated with incision (sub-type a). They are fully considered by Poursat, especially from the standpoint of motifs and consequently only lists of objects by site and inventory are offered here as a concordance to Poursat. A small number which do not occur in the ANM are given catalogue entries. The date and surrounding difficulties of the Cretan examples of relief carving will be discussed below pp. 302 and 311 f.

Type 63: 'Figurines'

This type includes small objects made of ivory or possibly bone carved in schematic shape of a human figure. They tend to be flat and rather two-dimensional. Most are from pre-palatial contexts on Crete.[39]

Type 64: Three-dimensional carving

This type consists of carvings in the round, mainly of human beings but also a few of animals (sub-type b). Apart from the acrobats from Crete or the so-called 'femmes debout' from some Mycenaean contexts there is little unity in this type. As has long been recognised the skills of the Mycenaean ivory carver (and possibly the Minoan) were directed more toward relief sculpture.[40]

Type 65: Pyxides pls. 13c, 25b.

This type appears in several forms which are fully discussed by Poursat (Iv. Myc. pp. 25 ff). They include tall examples, from a large segment of tusk; low round pieces usually with decoration in relief; and small thin-walled examples often undecorated which Poursat believes covered other materials. One example of the latter is known in antler from Ayia Irini (pl. 13c and below p. 281) but otherwise all pyxides are of ivory. Poursat also considers 'boat-shaped pyxides' (pp. 27-28). Objects in the ANM are listed only by site and inventory number in the Catalogue; others are given standard entries.

Type 66: 'Multiple compositions'

Under this heading may be included such items as boxes and footstools 'tabourets' which can be reconstructed from ornamental plaques (Type 62) or attachments in relief (Type 61). Recent excavations have yielded two of the finest examples: the 'footstool' from Archanes composed of figure-of-eight shields and warrior heads and another less complete example from Thebes with volutes covered by a graded series of figure-of-eight shields. A discussion of these multiple compositions may be found in Poursat, Iv. Myc. p. 29 ff ('Coffrets') and 31ff ('Tabourets').

Types 67, 68, 69, 70: Miscellaneous objects Figs. 121-22 Pls. 107-110.

Under these headings may be found a variety of objects, most quite small made from bone, antler, boar's tusk and ivory respectively. For some there are no clear parallels either among other types or among the other miscellaneous objects. Frequently there is no indication of their function, even in general terms. Sometimes it is not even certain whether the piece was finished. Catalogue entries are provided but not every worked piece of bone or related materials could possibly be included here. As elsewhere on the catalogue, classification, even under the heading 'miscellaneous' demands a certain standard of description and illustration in the literature.

The treatment of Type 70, Miscellaneous ivory objects is slightly different and refers to groups in Iv. Myc. ('pieces divers et pieces sans decor'). The method of presentation is explained on the introductory page to this type in the Catalogue.

GROUP X: PARTIALLY WORKED MATERIALS (Types 71, 72, 73, 74) AND RAW MATERIALS (Type 75) Fig. 123; Pls. 111-12.

Within this group five types are presented, one including unworked raw materials, the other four corresponding to the four kinds of material in this study, found in partially worked or waste segments. Clearly these 'types' are not types in the sense used elsewhere in this classification but merely serve to present the material in categories.

CHAPTER VIII

SITE STUDIES

INTRODUCTION

The real importance of any study of worked bone, ivory or related materials lies in a consideration of these industries at site level. Only at this level can one make systematic investigations regarding types of bones employed (as in Chapter II), and the interrelationship of tool types during a single period or through time, if the site is of long duration. Concentrations of unfinished and finished objects in certain areas of the site may provide clues regarding working areas and the organisation of site industries. Finally, one may attempt to assess the role of the bone industry on a site by examining the worked bone or ivory in light of objects, whether tools or finished items, in other materials.

For such site-based studies to take place at all, the objects must of course be examined at first hand. Published photographs and drawings, however, clear, are no substitute. Second, it is better if the site has been fully or at least substantially, published. This provides the student with a broad framework, both chronological and cultural, into which he can place his own findings. Additional site data such as original notebooks and plans may also be needed for a thorough analysis of the bone or ivory remains to take place. Finally there must be adequate information available regarding objects in other materials, especially tools in bronze and stone, not only by period but by area of the site. Much of this might be obtained from a final site report but consultation with experts working on other small finds would prove valuable in assessing the use of stone or bronze in bone and ivory working as well as the possible function of the finished products in bone.

Of course the criteria mentioned above are ideal and few sites could offer all these features together. However, concentration on single-site studies, particularly those offering substantial numbers of bone and ivory objects for analysis should prove one of the more promising areas of future research. Within the confines of the present study a more superficial approach to site studies must be adopted. In some measure this is due to the information at present available from those sites yielding good collections of worked bone or ivory. Of the five sites which have provided the bulk of information for this study as a whole, only Thermi is published and that offers its own particular problems (below). The four other sites, Lerna, Ayia Irini, Royal Road, and the Citadel House, are still in the process of study for their final reports and the amount of information regarding stratigraphy, pottery contexts and associated material has depended largely on the stage of study reached.[1] In no case has it been possible to obtain all the information necessary for a highly detailed site study such as described above.

Since these sites have provided much of the evidence for earlier chapters on materials and manufacture methods lengthy discussions on these matters would be unnecessary here. Instead we may focus on those features of bone and ivory working which are peculiar to the sites in question and consider some of the problems which affect our interpretation of the evidence.

THERMI

A description of Miss Lamb's method of presenting the Thermi bone has been given above (p. 195). Many of the objects are preserved in the Mytilene Museum (Thermi apotheke).[2] Since Lamb indicates in her report that complete records of the items were retained it was hoped that a correlation between these, the distribution chart in the publication and my own findings could be made. Unfortunately the bone records could not be located in the British School at Athens in 1979.[3] This means that virtually all the worked bone presented in the Catalogue from this site, apart from those items published by Lamb, are listed without 'dates'. Consequently the following discussion will rely on Lamb's distribution chart.

The Thermi bone industry, as others considered here, rests chiefly on bones from the domesticates: sheep/goat, cattle and pig. Fallow deer (Dama dama) bones and antler were recovered from the site, although no bones could be identified by myself among the worked bone. This may be explained by their similarity to cattle bones, particularly in the case of worked ribs. As noted elsewhere deer metapodials are ideal for the manufacture of long pins and may have been used for such at Thermi.

Tables such as provided by Lamb and illustrating the distribution of tools by period on a site may be quite useful in providing a general picture of the relative frequency of one type to another. However they are less secure in their value for comparisons between periods. Unless approximately equal areas of a site are excavated for each period, statistical comparisons of frequency of types become meaningless.[4] Upper levels of a site, possibly eroded after abandonment together with the effects of modern deep-ploughing, can be greatly distorted. This should be remembered before drawing any conclusions from the relative paucity of bone tools from Town V and perhaps even IV. A radical decline in the bone industry need not be the correct interpretation.

In view of these caveats, what can be said of the Thermi bone industry? It seems to have relied principally on two tool types (Lamb's 4 and 5: our 5 and 12). The overall numbers are comparable and they appear in roughly the same ratios in each period. Rib bone implements are rather more frequent in Thermi IIIa and b while split metapodials (Lamb 4) increase a little in IIIb. These ratios might suggest that the tools were completely interchangeable and that they could fulfil a given function or functions with equal ease. That is, our separation of these objects into two types on the basis of different bones has no practical reality apart from the narrow typological aims.

In fact, a closer examination of the actual objects shows variety in working ends, not only between the types but also within each type. Difference in working ends may be a much more reliable clue to different functions. In that case, the similarity in absolute quantities allows several observations. First, the two principal tool types seem to have been well suited to their particular tasks. Slight modifications within a type might have occurred but these cannot be detected with the present information. However, no major change in the manufacture of these types occurred. Second, the continuity of these tools especially in Towns II-IIIa, but also into Town IV suggests continuity in the activities for which these tools were made. That is, had the activities altered significantly, it is unlikely that identical tools would have been suitable. Finally the drop-off in the numbers of tools (period IV) is not marked by an introduction of other types.

Of the other implements, only Lamb's types 1, 2 and 9 are sufficiently frequent to be considered as significant groups in the Thermi industry. The existence of Lamb's chart is particularly valuable in the case of type 2 ('Sharp gouges', our Type 1) since only four possible examples of this type could be found in 1979 which would have given a most distorted picture of the Thermi industry.[5] The existence of tools made on pig fibulae (our Type 3) has been noted in Chapter II and their numbers suggest that at Thermi, at least, there was deliberate selection of these bones since their occurrence is not confined to a few strays.

Thermi, in common with many other sites, has a much smaller number of blunt implements than pointed objects. Most are included in Lamb's type 1 (our Type 15),[6] the remainder are represented by a handful of Lamb's type 3 (double gouges, possibly our Type 18) and Lamb's type 13 (pig fibulae, our Type 17). These last two are so infrequent as to suggest their occurrence was in the nature of 'casual blunts' and that the most successful bone blunt was that made on whole long bones. The relatively low proportion of blunt tools here and elsewhere, may be explained largely by the existence of other materials, chiefly stone, but also shell, which could provide implements with broad, flat working ends, to fulfil such possible functions as scraping, polishing and pounding.

Antler, at least as represented by Lamb's chart and in the extant collection, seems to have had little impact on the Thermi industry.[7] Whether fallow deer antler is a less suitable medium than that of red deer is beyond my own experience. Whatever the reason, the inhabitants apparently either did not recognise the inherent qualities of the material (Chapter II) or had no need to exploit them.

On the whole, Thermi seems to have a fairly generalised bone industry relying chiefly on three or four pointed types and one blunt. These types are fairly unexceptional and may be found elsewhere in the Aegean. Most striking is the high number of rib bone tools at times surpassing the number of split metapodials. A similar predominance in the use of ribs may be detected at Poliochni (especially Blue) and Troy (mainly I, II). Only in the case of pins is the Thermi industry truly remarkable, not only within the region but also for the Aegean as a whole. Although classed with Type 11c (pins with decorated heads) the Thermi examples have no close parallels elsewhere for such long and elaborately carved heads, decorated with incision (fig. 72).

LERNA

Lerna offers the most extensive collection of worked bone and antler for the Greek mainland during the bronze age. Apart from about 200 items of the neolithic period, the remainder, nearly 800 objects come from bronze age levels, principally Lerna III-V (EHII-MH). There is no EHI at Lerna and a hiatus separates the neolithic from Lerna III. Contexts called either mixed fill or II (late) - III represent disturbed layers caused by EHII levelling for large structures such as the House of the Tiles.

As indicated above, the Lerna worked bone was included in Banks' study of the small finds for a Cincinnati doctorate some 15 years ago. Banks had access to site records as well as the objects themselves. In addition to her catalogue she was able to offer details of objects in other materials found in the same context as bone implements. However, only rarely could inferences as to activities in particular rooms be made from the associated material.[8] It is hoped that as work on the final publication proceeds more precise information about contexts and finds will be available.[9]

We must start our consideration of the Lerna bone industry with an evaluation of Banks' conclusions since they demonstrate the dangers of non-adjusted comparisons between periods on a site. She states at the beginning of her conclusions on bone:[10] 'Bone was not a favoured material with the inhabitants of Lerna III . . .' She goes on to mention that only two groups of tools are found exclusively during that period ('Rib bone awls', our Type 12; and bone tubes with notches, our Type 35). Her assertion regarding the preferences of the Lerna inhabitants during EHII is a serious one and cannot stand unchallenged as it reflects a fundamental misinterpretation of the evidence for that period.

There are few pure Lerna III contexts yielding bone implements: many are II-III mixed while others seem contaminated by Lerna IV bothroi. Although many of the tools from these mixed contexts can be earlier or later, some could indeed by Lerna III. Banks does not seem willing to accept this.

Second, and of utmost importance in any discussion of Lerna industries is a consideration of the nature of the pure Lerna III deposits. The site as excavated revealed major fortifications and an early monumental building (B/G). Some houses within the fortifications were also excavated. These were demolished together with building B/G during the latest phase of Lerna III in order to construct the House of the Tiles. At this period the fortifications may have been under reconstruction as well. The major features investigated are therefore monumental structures, not domestic housing with courtyards and streets, such as characterise true 'settlement' deposits, and which are known from the succeeding periods of the site. The recovery of bone tools from the House of the Tiles (had it been completed) would be as surprising as from the heart of a later palace. That these characteristics of Lerna III should be overlooked by Banks, a member of the excavating team itself is most regrettable.[11]

Next we must consider the evidence of the types of tools which do occur in Lerna III. Banks' statement regarding the ribs is misleading since not every single example in her catalogue comes from a pure III context. Furthermore, other types of bone tools do occur during this period, notably her 'extremity-bone awls' a) and d) (our Types 3 and 5 with some unclassified). These types she states come from contexts 'late in the period in levels which would naturally be subject to contamination from adjacent levels of Lerna IV just above them.' It should be noted that her a) and d) awls do indeed start in Lerna IIIc, but there are no rib awls earlier than IIIc either. Banks has unfortunately reached conclusions which do not seem to have any secure foundation in the evidence.

It may seem that these criticisms of Banks are unduly harsh, since our own distribution chart (Table 8) does reveal a fairly small number of bone tools from the EHII period at Lerna and ribs (Type 12) do indeed seem to predominate. Our chief concern here is that Banks has allowed her preconceptions regarding the Lerna bone industry and perhaps the site as a whole to colour her comments on individual types and even specific tools throughout her study. Consequently because 'extremity bone awls d)' are 'essentially Lerna IV-V types' in Banks' view, virtually all those from III c-d contexts are dismissed as either neolithic 'throwups' or IV contaminations. Yet rib bone awls placed firmly in Lerna III by Banks and in spite of her assertion that these tools were 'well-established' in the neolithic, here none of the Lerna III examples were regarded as anything but Lerna III.[12]

The difficulty with interpreting the Lerna III evidence is not only the comparatively low numbers of bone tools and restricted numbers of types, but the very existence of such buildings as the House of the Tiles. The site is regarded as having a high degree of material culture at this period; a culture relying on bronze for its tools. Indeed Banks believes that 'the place of pointed bone implements was taken by bronze tools such as the square-sectioned awls which were current in Lerna III.'[13] There are 5 such awls from Lerna III contexts and 5 from the succeeding period which Banks claims are indistinguishable from the Period III examples.[14] The remains in bronze do not in fact support the view that bone was subsidiary to bronze during the Lerna III period. On the contrary it would seem to support the contention that the site, as excavated, has yielded few of the domestic contexts which would yield tools in any material.

Attempts to assess the role of the Lerna III bone industry are particularly important as a basis for comparison with Lerna IV and the apparent cultural change occuring after the destruction of the House of the Tiles. On the surface it does seem that bone may have played a greater role in the industries on the site in period IV. The absolute numbers of tools recovered are substantially higher and a greater diversity of types may be seen. But does this really lend support to a picture of a 'rough folk . . more at home with Stone Age materials' (i.e. bone and stone)?[15] First we must tackle two related preconceptions about bone industries as a whole. One is that the use of bone tools, by definition, reflects a primitive culture and seccndly that bone is inferior to bronze for all purposes. To this we may add the view that the principal implements of the bronze age were bronze tools.

The bone tools of Lerna IV are for the most part well made and are not crude casual implements. Indeed, the use of sheep/goat metapodials, especially metacarpals, for Type 1 pointed implements and sheep tibiae for Type 15 blunts may demonstrate conscious selection of material and an understanding of the inherent characteristics of certain bones (Chapter II). The general impression is of a fairly long tradition of bone-working behind the Lerna IV tools.

It is the quality of the Lerna IV products and the range of tools types which are rather more important than increased numbers of tool in assessing changes. Among the pointed implements, there is considerable variety, especially in the shape of working ends, perhaps suggesting correlation between tool type and specific function. There is also a good range of blunts, notably Type 15, 18, 19 and 20 which predominate in period IV. It is certainly tempting to equate the diversity of tool types with the appearance of new inhabitants in Lerna IV: people who not only relied heavily on the use of bone for a wide range of activities but who also produced bone work of good quality. This may, indeed, prove to be the correct interpretation.

Yet we must remember that all such comparisons between the bone industries of Lerna III and Lerna IV are unbalanced. Without the necessary domestic contexts of III, especially in the final stages, we cannot really assess whether those types apparently linked with the new inhabitants of the site are genuine innovations brought from outside, or whether they would have developed naturally at Lerna had there been no destruction.

In contrast with the difficulties surrounding the worked bone of periods III and IV the transition to the succeeding period seems fairly straightforward. Banks is quite correct in stating that in many cases implements of a given type produced during Lerna V are indistinguishable from those of period IV.[16] For the most part the tool types of Lerna IV continue into V although in reduced quantities. This should not be ascribed to less reliance on bone as a medium for tool making but rather to the quantity of excavated material from the site. The disappearance of three main classes of blunt implements and the significant reduction in numbers of two others (see Table 8) is, however, noteworthy. This implies either the complete cessation of those activities which demanded bone tools of such types or else a change to new tools in other materials.

The most striking features of the Lerna V industry are the bone pins. Plain pins (Type 11a) do occur earlier on the site but their principal distribution is firmly fixed in Lerna V. Pins with simple heads appear in Lerna IV [17] but numbers increase dramatically in period V. The same applies to Type 11c pins with highly decorated heads which are almost exclusively products of Lerna V and later. As discussed above (Chapter IV) there is little evidence on the site for the manufacture of bone pins and no certain working areas have been isolated (p. 166 and n. 45). However, the refinement of some of the more elaborate examples (pls. 72-3) suggests an underlying understanding of the potentials of the raw material, possibly as a result of a long tradition in bone working. It may also imply some degree of specialisation in their manufacture.

Lerna is not unique in producing fine pins during the MH period and there is some truth in Banks' assertion that in variety and quality the Lerna examples surpass those found on other mainland sites. This may, however, simply be a consequence of the volume of MH material excavated at Lerna in comparison to other sites. As for quality, this is a difficult state to compare when relying on published information for parallels.[18]

The occurrence of a hammer-headed pin in Lerna V (11c: 36) and a fragmentary example from a mixed context (11c: 59) is of some interest.[19] Within the Aegean area, both Asea and now Lefkandi have produced examples in bone while one in gold was recovered in the Cincinnati excavations at Troy (IIg).[20] The type has a wide distribution throughout central Europe although no examples illustrated by Childe are exact parallels for the

Lerna pieces.[21] There is no reason to believe that the Lerna hammer-headed pins are anything but local products since in technique they are comparable to other Type 11c pins. The inspiration for the form, may, of course have been derived from elsewhere.

Little can be said about the bone industry in the successive periods of the site. No settlement deposits were recovered in connection with the shaft graves although bone implements and pins were recovered from their fill and in the vicinity.[22] There is one distinctive type of tool which seems to occur at this type (Type 13) but otherwise few implements were recovered. Pins continue but are slightly different from their Lerna V predessors, having extremely slender shafts and heads (fig. 71). There is even less evidence for the bone industry during Lerna VII but that is completely in accord with the general scarcity of remains from that period.

AYIA IRINI, KEA

The site of Ayia Irini, with occupation from the EBA through the LBA is of major importance for our understanding of the bone and ivory industries in the Cyclades (below pp. 314 ff). The site has yielded some 300 objects of bone, antler, ivory and boar's tusk as well as worked shell (pl. 16). The material from the site is in the course of study for final publication.[23] At present, some 25% of the objects in the bone inventory are still without 'date' and are included in the Catalogue with the symbol '?'. This does not mean that their context is unknown or mixed (XM, Y) but simply that the associated pottery has not been completely studied.

Nonetheless, it is still possible to make some general observations about the nature of the bone industry on the site. The number of objects from EBA contexts is relatively low but this is in keeping with the small amount of EBA material recovered owing to the presence of later structures. Types 5, 7 and 9 all made from segments of long bones are represented by a few items as well as Type 12 implements made on split ribs (pl. 7). One tube has also been recovered from a Kea II context but neither this, nor later examples, are decorated in the manner known from other Cycladic sites (Type 35b).

A wider range of implements is present from MBA levels on the site (Kea IV and V) but may be due more to greater quantity of the material recovered for these periods than to any major change in the nature of the industry. Notable are the Type 1a and b and Type 4a pointed implements, some of the latter using exceptionally long segments of cattle or deer metapodials. Pins also occur in this period including some with simple heads.

The domesticated species, sheep/goat, cattle and pig are all represented in the worked bone industry at Kea in the MBA. Antler is found in waste form but only few finished tools have been recovered. One tiny fragment of ivory in the form of a pierced disc (51a: 1) is, according to preliminary dating, from a period V context. It seems to be true elephant ivory, but boar's tusk cannot be wholly discounted. The recent find of unworked ivory from MBA levels at Phylakopi (p. 49) accords with the Kea evidence.

By far the greatest proportion of our evidence from Kea is from the late bronze age levels of the site, especially Kea VI

(LMIa) and VII (LMIb/LHII). The majority were found in House A. Bone tools, especially pointed implements continue as before and worked antler provides blunt implements in the form of tines (Type 22) and celt-shaped tools (Type 24).

Pins with simple and decorated heads occur from these contexts including nine from House A. Two are decorated with herringbone, that with its off-set head is unique (11c: 7, pl. 71). On the whole fine objects from this period are few, but those which do exist give clues to the prosperity of the settlement during the first part of the LBA and to overseas connections. The presence of ivory has been noted above (Chapter II), together with possible reasons for the lack of many objects in this medium (p. 51 and n.82). There is some reason to believe that ivory may have been worked on the site itself (Chapter IV, pl. 49a). The piece is from a period VII context although as that area of the site has not yet been fully studied no information regarding associated material is available. Some of the finished pieces do, however, suggest ready-made imports.

The comb (34a: 6, pl. 25a) from House A (period VI/VII) is undecorated and not divided into registers as most other undecorated combs are. It does in fact, have slightly more affinity to the combs Type 34c ('peigne à corne') with their slightly upward curving handles. Whether this was a local product or an import from Crete or the mainland cannot be determined. The fragmentary ivory pyxis, also from House A, might well be an import, although its origin too must be uncertain. The use of incision is fairly rare in Aegean ivory carving, especially on larger compositions. At this period (LHI-II) the 'peignes à corne' and discs are the principal items decorated in this technique but a thin-walled pyxis with incised decoration is known from the latest grave (I) in Circle A (LHI-IIa).[24] It is also interesting to recall that an undecorated pyxis of antler has been recovered underlining the use of local materials (p. 31, pl.13c). Small undecorated pyxides in ivory are known from mainland burials (e.g. ANM 6444, Poursat no. 324).

Much clearer indications of origin may be seen in the delightful ivory disc (49b: 1, pl. 25c). The parallels between this and the bone discs covered in gold leaf from the Mycenae shaft graves (IV and V) or the LHIIa tholos at Kakovatos are so close as to suggest an import rather than local copy.[25] The boar's tusk helmet plaques from Kea also point to mainland connections at this time. These may have been locally produced as the material was available and other items from boar's tusk have been recovered from various levels of the site. The plaques, while insufficient now to reconstruct an entire helmet, are of canonical form. They too come from House A, period VII (pl. 14c).

Several other small items are worth mentioning in respect of the wider connections of Ayia Irini during period VI and VII. These are the figure-of-eight attachment (61: 4), which apart from material is identical to those known from the mainland and Crete; the plano-convex inlay (56b:1, pl. 3b) with bronze pin is similar to Cretan inlays in bone. Finally there is a bone moulding strip with grooved decoration (59: 1) which has many parallels both on Crete and the mainland in the middle or late bronze age. The Kea example is from a period VII context.

This brief survey indicates that during the late bronze age, if not earlier, Kea's local bone industry was producing non-essential goods current elsewhere in the Aegean, sometimes using locally available materials in place of ivory. In addition, certain luxury goods of ivory were probably being imported onto Kea ready-made. These connections tend, on evidence available, to point toward the mainland rather than Crete, although any generalisation based on so few pieces must be cautious. Equally significant is the continuity and development of the traditional bone and antler industry throughout all bronze age levels of the site.

ROYAL ROAD, KNOSSOS

The ivory deposit on the Royal Road, Knossos provides us with evidence of an entirely different nature from that which we have discussed previously. The principal deposit, that of workers' waste and finished pieces, represents a palace workshop of a single period.[26] The range of products, as preserved, is fairly limited, yet of a high degree of workmanship.

In evaluating the evidence from the site then, we are not concerned with distribution over time of various types of objects nor attempting to suggest possible function in the basis of associated material as on settlement sites. The chief value of the Royal Road deposit is in providing information about a palace industry at a fairly precise period during the bronze age. From the objects and the waste material we may learn about aspects of manufacture methods and techniques, (above Chapter IV).

The principal types of objects recovered from the deposit are plain inlay plaques (56 a-c; figs.112-18). Few of these are peculiar to the Royal Road although in terms of material used and possibly treatment they are unparalleled. Most of the known comparisons are in fact earlier and come from first palace period contexts at Mallia. Bone squares, plano-convex plaques and strips are all known there. It would seem that the tradition of inlays then, is long and development fairly conservative. Bone and ivory plano-convex inlays also exist from the Evans' Unknown Provenance material (Appendix IIa) but whether these come from earlier contexts than the Royal Road pieces cannot be determined.

Of the other items in the workers' debris little can be said. The fragmentary comb, (34a: 8) and hooked pins (Type 11d) as well as a few fragments with relief decoration (pl. 108) suggest that items other than plaques were manufactured or assembled there.[27] More precise information regarding contexts will probably permit a more detailed evaluation of the nature of the deposit in the final publication.

The principal features of the deposit from the point of view of ivory working techniques have been fully discussed in Chapter IV and need only be summarised briefly here. The precision of manufacture suggests highly skilled craftsmen, possibly specialising in ivory-working alone, with considerable familiarity in working the material to its best advantage. This is noticeable particularly in the manner in which the small plaques have been cut from the tusk (pp. 94 ff). The re-use of larger waste pieces for secondary processes such as peg manufacture also argues for an artisan of skill since it not only demonstrates economy of material but also necessitates careful selection of suitable waste pieces to prevent the small ivory pegs from splitting.

The precision of the work also suggests the use of bronze tools, as is confirmed by the regular appearance of the manufacture marks. However, at present no specific tools can be linked to the different types of marks represented apart from the tubular drill in the production of pegs. In addition there is a strong case for seeing the workshop operating some form of 'mass production'. That is, the repeated manufacture of identical objects with work, very likely, occurring in stages. Unlike more individualistic objects which might better be produced by a single craftsman from start to finish, a number of such items as inlays may well have been roughed out before more accurate cutting and finishing took place.

THE CITADEL HOUSE, MYCENAE

The Citadel House, Mycenae, offers a unique collection of partially worked ivory as well as objects in bone, ivory and antler from the LHIIIb period. Some of the finished ivories are of well-known Mycenaean types, while others are unparalleled in the published material. Although the site as a whole is unpublished, study is well advanced in various aspects of the material and the initial fascicle of the final report should be forthcoming in the near future.[28]

The exact role of the area known as the Citadel House and its relationship to the rest of the citadel is not entirely clear although the function of individual 'rooms' on the site may be inferred from the architectural remains and finds. As indicated elsewhere, the interpretation of the ivories on the site is also not easy and the identification of an ivory workshop within the Citadel House is not wholly certain.

The most important examples of partially worked ivories from the site have already been considered above (Chapter IV). In this chapter we will examine these and other objects of bone, ivory and antler by area of the site in order to present a more complete picture of the Citadel House evidence and to evaluate the case for the existence of an ivory-working area on the site.

Three principal deposits of bone and ivory remains occur on the site, namely Room II (basement room of the Megaron, Room 2); the 'Workshop area' (Gamma 21) and the 'Shrine' (Room 32). Three further areas have yielded important, although small groups of material: the 'South House' Room 7; the 'Room with the Fresco' (Room 31) and the Temple ('Storeroom of the idols'). All of these groups are in closed LHIIIb contexts brought about by the partial destruction of the site during that period. About one-half of the total bone and ivory remains have been recovered from these contexts.

A number of objects come from the destruction debris resulting from the major catastrophe which destroyed the site toward the end of the LHIIIb period. There are few items from floor deposits associated with the destruction and the excavator has noted that almost all finds in the debris must have come from upper stories or from buildings higher up the slope to the east.[29] A significant number of objects occurred in later contexts with pottery of LHIIIc date but containing earlier material as well. The mixed nature of these contexts seems to have been due to extensive terracing. Finally there is a small number of items which have been assigned 'Mycenaean or post-Mycenaean date'. In fact, in most cases these bone and ivory remains conform well to Mycenaean types.[30]

Rooms I and II

The basement rooms I and II which provide an interesting but not homogeneous group of ivory remains, have already been mentioned in connection with the discovery of the hippopotamus lower canine (above Chapter II). This piece is apparently unworked. Similarly unworked are 11 boar's tusks of which seven are complete. A further two tusks seem to have had their tips removed. Another group of items from the room are the lily and rosette inlays (58: 2 and 58: 11) as well as inlays strips of varying widths (56c: 14, 32, 36, 37-39). These are all finished pieces. Three other inlays listed with partially worked ivory (74: 15-17) are not certainly unfinished pieces, although in their present state it is difficult to be certain. Finally there are two curious items (70: 25 and 26) which may or may not be finished. The latter has grooved decoration along one edge and may have been some sort of attachment for furniture as rivet holes are present in the lower and more roughly finished portion. Only one item of bone, the 'cosmetic spatula' (28: 2), was recovered in this room.

There is very little evidence to indicate that this room was used for ivory working per se, in spite of two tiny pieces of scrap ivory and a few pieces which might be unfinished. According to the excavator, masses of pottery was also recovered from these basement rooms which might support the notion that they were storerooms of some sort. The ivory remains would not be wholly inconsistent with such an interpretation.

The Workshop Area (Gamma 21)

An open area with complete vases and a quantity of small objects including bronze and antler implements and a steatite mould has been designated the 'workshop'. The area has also yielded objects in bone and ivory. The first group which we may consider consists of tools. There is a fine bone needle (10c: 10); three pointed implements of antler (13a: 3-5, fig. 77) and a blunt tool of the same material (25: 7). The antler implements which have parallels elsewhere on the site are of especial interest in view of the discovery of another such implement in the LHIIIb jewellery workshop in Thebes (Kouropoulos plot, 13a: 11). In the Citadel House workshop area a large number of minute beads in stone and possibly bone have been found.[31] A bone handle with bronze awl still intact was also found here (37a: 19, fig.105).

Whether ivory working took place here is unclear from the existing evidence. There are two apparently finished objects in ivory, a wide strip (56c: 40) and the mushroom-shaped attachment (61: 24, colour plate Va). In addition there are fragments, probably from wide strips (NC: CH-66: 1802, 1720) and a T-shaped inlay (70: 27). There is also a portion of a plaque with mortise on the underside (70: 28). All of these also appear to be finished products. The only possible clue to ivory-working in this area is the partially worked segment (74: 18) which, as discussed above, may be waste rather than a roughout (p. 130, pl. 42c). Its nearest parallels are the partially worked pieces found in Room 32 (below).

The only other items from this area are an unworked segment of bone, a tiny unworked segment of boar's (or pig's) tusk and a curving cylindrical piece of bone, originally described as a pin but probably an unworked bird bone (all NC). These seem to be stray debris rather than waste from bone or ivory working. It is certainly possible that ivory working occurred side-by-side with other crafts which were practised in the workshop area. The lack of off-cuts as found on the Royal Road or in the 'artisan's workshop' on the Citadel itself is however surprising if ivory-working did in fact occur in this area of the site.[32]

The Shrine (Room 32)

The group of ivory objects found in the northern part of Room 32, a small room leading off from the 'Room with the Fresco' (Room 31) is among the most interesting found anywhere on the site. It includes the principal pieces of partially worked ivory recovered from the Citadel House, most of which have been discussed in some detail above (Chapter IV; 74: 19-26). Also found in the room were several bone and antler tools and a few finished ivory objects.

Also in the northern part of the room were two vats of unbaked clay with glass beads and steatite 'spindle whorls' while on a rough platform of plesia in the south-west corner stood a 'goddess'. Many intact vases were discovered on the floor.[33] The room is very small indeed and the objects recovered from it, not least the group of partially worked ivories, strongly suggests that it was being used as a storeroom. The presence of the 'goddess' would not necessarily contradict that interpretation.

Since the partially worked ivory has been discussed already, little more need be said about it here. A possible link between these items and the partially worked piece (74: 18) from the workshop area may be recalled. A further link between the two areas may also be provided by the two antler implements (13a: 6, 7) found in Room 32 and more of the tiny beads (above n. 31). The pointed implement made on a rib (12b: 25) is one of the very few late bronze age examples of this type. The ivory strips (56c: 33-34) are similar to those known from elsewhere on the site.

Neither the small spoon (27: 4) nor ivory knob (42a: 4) have exact parallels but do fit into their general types. Quite unique, however, are the two pronged or fork-like objects (61: 25-26, pl.106). They are almost identical in dimensions apart from slight variations in the placement of rivet holes. Their purpose cannot be deduced beyond their possible use as some sort of attachment indicated by the holes and preserved bronze rivets suggest.[34]

Finally there is 70: 29, a wedge with moulded edge (fig. 11b). Again, the purpose of this piece is unclear and the rather vague designation 'furniture decoration' might be applied in default of more certain information. Since both this and the pronged objects seem to be intended as portions of larger objects or fittings of some kind, it seems that they were merely being stored in this room until final stages of assembly could take place elsewhere. The room itself is certainly too small for ivory working. Nevertheless the presence both of finished and partially worked pieces here certainly points to ivory working taking place somewhere in the vicinity.

The South House: Room 7

The other three areas with closed groups of LHIIIb ivories have fewer objects but ones of considerable interest nonetheless. From Room 7 in the 'South House' come a knife with bone or ivory handle (38: 3); a much decayed inlay, just recognisable as a figure-of-eight (61: 10) and a small pin fragment (11e: 21). These are all of quite conventional appearance. Apparently unique is the ivory model of a dagger (61: 23), clearly designed to be attached or inlaid because of scoring on the underside. The piece has been discussed in connection with the effects of high temperatures on ivory (above p.104, pl.104). Finally there is a curious piece with two long parallel edges and one preserved side cut off obliquely (70: 30, pl. 37c). The upper portion of the piece is narrower in section than below. This seems deliberate and is not the result of damage done to the piece by high temperatures. Nevertheless the present condition makes it impossible even to tell whether this is only a partially worked piece or a finished one. Certainly it made up part of a larger composition as there are remains of scoring on one edge. It may be, as the excavator has suggested, part of an ivory box.[35]

Room with the Fresco (Room 31)

The 'Room with the Fresco' has yielded two of the most important individual ivories from the site, namely the head of a young man and a recumbant lion.[36] The room itself was clearly of some importance as the fresco and altar with horns of consecration indicate. Also discovered in the room was a Minoan stone bowl and a fine ivory sword pommel (43: 13, pl. 33b, c).

In the debris of the minor destruction which took place during the LHIIIb period were found several more ivory remains. After this the room seems to have been partly filled in and in the southern part, stone slabs were laid on the earth.

The fine state of preservation of the ivory head (64a: 14, pl. 54) is in part due to the fact that during the first destruction the room itself was not burnt. Why the head and lion were not removed from the debris before the room was filled in has not been explained. Although the lamination lines are clear on the head only in a few places has the ivory split away. The front of the nose and side of the neck have been damaged. Noteworthy are the holes, of which two small and one large at the side have been preserved. This indicates attachment to another item but whether merely a stand or a wooden body as suggested by Hood cannot be determined.[37] The head poses further questions regarding its origin. Poursat has suggested that the piece may be an import [38] and it is certainly true that it is quite unlike any other extant Mycenaean ivories. On the other hand, there are similarities, as Hood points out, between this and the plaster head with painted features from Mycenae and also probably of LHIIIb date.[39] The ivory head is, however, only about one-half the size of the plaster example, dictated in part by the limits of solid material available from a tusk.

Similarly unique is the couchant lion (64b: 2) which measures nearly 0.18 m. long and is carved from a large section of the tusk. Unfortunately since discovery, the condition of the ivory has deteriorated considerably.[40] The fine quality of carving is still visible especially in the treatment of nose, nostrils and paws.

The mane is indicated by incision. In fact, the carving is not wholly in the round since on the underside is a rectangular mortise, presumably for attachment to a base.

The other ivory remains from the room are less exceptional. The pommel, although finely worked and well-preserved is of conventional type. Also recovered were a decorated pin (11c: 73), one of the problematical Type 41 objects described variously as 'hilts' or 'pièces de lyre' and a grooved moulding (70: 31). A small irregular scrap of partially worked ivory was also found in the debris.

Storeroom of the idols

The final group of ivories, that from the 'Storeroom of the Idols' also contained several unique pieces. These small, finely worked objects were discovered in a bowl with groups of ornaments and semi-precious objects in other materials. This is now known as the Pot Group.[41] The first object, an ivory comb, undecorated with two registers is of standard appearance (34: 18). The delicately carved object in the shape of an arm with clenched fist at one end is, however, quite unparalleled (pl. 55 , fig. 97). It has been tentatively grouped with the 'cosmetic spatulae' (28: 3). The remaining two items are also unique: 64a: 15 a small ivory figurine in seated position (pl. 55 , fig. 122) and a bead (51b: 3 , pl. 55). Study of these items is only at a preliminary stage but it is possible that they are imports. The same might be true of the arm.

Other objects from the Citadel House

As already indicated about one-half of the objects from this site do not come from the closed deposits in the areas discussed above. Nonetheless they include some important items and it may be hoped that further study will be able to link some of them more closely to specific areas of the site than has been possible at present.

Of the objects found in the LHIIIb destruction debris the most important is the partially finished plaque (74: 28) discussed above. Two mouldings, one with grooved decoration (70: 33) and the other possibly unfinished also come from the debris.

Two examples of partially finished pins, one of which was recovered from a floor deposit, deserve mention (see above p.126f). The remainder of the items from this destruction debris can only be listed briefly. They include pins (Type 11 a and b), needles (10 a-c) and a fine comb (34a:19). Two antler implements (13a: 8, 25: 8) a bone tube (35: 23), an ivory strip (56c: 15) and two 'cosmetic spatulae' (28: 4-5) are the items most worthy of note.

The type of objects from mixed LHIIIc and earlier contexts is rather different. A very high proportion are bone pins (11a, b, and e; 11c: 74-80), which are comparatively rare from the mid-LHIIIb closed deposits discussed above. A strip, an antler implement and tube as well as two ivory objects of unknown use (70: 35, 36; pl.110 a,b), have been found in these mixed contexts, but all could well be of LHIIIb date. Pieces of partially worked or perhaps scrap ivory (74: 29-33) constitute a significant proportion of this LHIIIc and earlier material. Some of these pieces were discussed above (p. 131 f.) in connection with stages in ivory working but others might well be waste pieces. There are also several segments of partially worked bone (71: 12-14). Since the material from these contexts is mixed due to terracing, many if not all the partially worked pieces may well be from the LHIIIb period. These pieces taken with the larger examples of partially worked ivory stored in the 'Shrine' give strong support to the theory that ivory working took place in the Citadel House area. At present however, it is not possible to determine the precise area where this ivory working took place, whether it occurred in conjunction with other crafts and what sort of end-products were manufactured.

CHAPTER IX

REGIONAL SUMMARIES

INTRODUCTION

The basic aim of this thesis has been to tackle some of the broad technological questions connected with the working of bone and related materials. The discussions have, by necessity, centred on a fairly small number of pieces which provide evidence for the use of these materials and manufacture methods during the Aegean bronze age. By contrast, the typology and its associated catalogue has attempted to rationalise the rather disparate treatment of much of the published and unpublished material in bone and related substances. It should, therefore, serve as a basis for analysing regional and chronological variations in the bone and ivory industries of the Aegean.

Brief comments on the distribution of individual types have been offered in the chapter on typology (Chapter VII). Here an attempt will be made to integrate some of this information with those features of bone and ivory working considered elsewhere in this study. The four main regions: Crete, the Mainland, the Cyclades and the North-east Aegean will each be examined in respect of the developments in their bone and ivory industries throughout the bronze age. Discussion must remain brief and can only hope to summarise some of the more important aspects while pointing to those problems which affect our interpretation of the evidence.

CRETE

The most striking aspect of the bone and ivory industries of Crete must surely be the unbalanced nature of the evidence itself. While argument *e silentio* is dangerous, it is nonetheless apparent that some of the gaps in our picture are caused by the sort of sites investigated during the history of excavations on the island, as well as an all too common bias towards objects of value or artistic merit. Briefly, this has resulted in a number of fine objects of ivory being recovered from bronze age contexts but hardly any evidence for a more traditional bone industry producing common items such as bone tools.

From the early bronze age we have virtually no information about bone tools. The number of examples is insufficient to build up a picture of basic types of tools encountered much less to gain an idea of the position of worked bone in the pre-palatial culture of the island. Here the sort of sites excavated has most militated against our knowledge of bone working since the majority from this period are burials. Bone tools are not found in such contexts although that is no reason to suppose that the communities using the tombs did not use such implements.

A handful of bone implements has been reported from the older excavations of pre-palatial settlement sites, but these provide little information. More might never have been recovered or preserved; it is difficult to tell. It is therefore, doubly unfortunate that the excavations at Myrtos (Fournou Korifi) should have produced such a meagre amount of worked bone. This was not through any lack of attention to detail but rather, it seems, due to erosion and soil conditions on the south coast of

Crete which similarly affected the faunal remains from the site.[1]

Although derived primarily from Knossos, the evidence suggests that during the neolithic period, Crete had a flourishing bone industry. Pointed implements on sheep/goat metapodials and cattle ulnas and a variety of blunt tools have been recovered in great numbers from the investigations into the neolithic levels at Knossos.[2] It is hardly likely that with the onset of the EBA such an industry vanished overnight. This applies, whatever view one may take of the development of culture on pre-palatial Crete.[3] There is certainly no reason to suppose that bronze tools replaced bone implements for all activities. We need not conclude that Crete had no bone industry during the EBA, merely that evidence for it has either perished or awaits discovery.

The dearth of information about bone tools from pre-palatial Crete is, in part, offset by the new evidence for the use of bone for Cretan seals. Although the precise chronology of the bone seals cannot be established, the possibility exists that seals made from these locally available materials may be earlier, not just stylistically, but also chronologically, than those made from ivory.[4] It is also important to note that the types of bone encountered in seal manufacture are also ones which are most common in bone tool manufacture, notably sheep/goat and cattle long bones.

This new evidence for the use of local materials in Cretan seal manufacture, coupled with the calculations regarding the number of tusks represented by the extant ivory seals, must surely lend support to the theory that the use of ivory during the EMII period was fairly limited.[5] Nonetheless, the new evidence of the hippopotamus lower canine from Knossos does prove that one form of ivory was reaching Crete and being worked, almost certainly in the EMII period (p. 70 ff).

We may now consider the impact which the introduction of ivory had on bone working during the pre-palatial period. First, we may recall that the term 'bone industry' may be applied to the manufacture of implements demanded by the occupations of a site, whether in treatment of skins, sewing, burnishing or incising. Such an industry may also provide 'non-essential' items including objects of personal adornment, figurines, pins and on Crete, seals. I have argued elsewhere (Chapter IV) that some of these may display specialist skills in their production, notably from the handling of the raw materials, unlike the manufacture of bone tools. We need not envisage 'full-time' craftsmen devoted to such activities, yet the beginnings of specialisation may be detected. With the introduction of an imported luxury good, such as ivory, such skills would be all the more important. Although not radically different from the related bone or familiar boar's tusk, it does require careful handling, if only to prevent undue wastage.

Off-setting any disadvantages of working with an imported material were surely the benefits of working without the constraints imposed by the natural shape of bone or boar's tusk. A much wider range of shapes could be produced. Larger seals, with two seal faces or grips carved in the shape of animals could be produced. Freedom in the shape of the raw material could allow considerable experimentation. Yet all of this is considerably removed from the manufacture of a bone tool, or even a simple ring-shaped seal in bone, which as stressed above, are relatively simple matters once the basic skills are learnt. This, in my opinion, demonstrates that already in the pre-palatial period a split was taking place between the 'traditional' bone industry on one hand and the 'bone/ivory' industry on the other.

This 'bone/ivory' industry continued to produce small non-utilitarian objects even when these materials went out of vogue for seal manufacture. The overlap in use of local and imported materials seems to have continued for some time on Crete, while in other areas, for example Ayia Irini, it continued well into the LBA. The use of ivory after all depends on the ability to acquire the raw material by trade, whether direct or indirect.

As discussed above (Chapter II) our picture of the bone and ivory industries during the first palace period is clouded by the nature of the deposits from that period. Mallia and Phaistos provide the best evidence, but even this is patchy. Noteworthy is the existence of the 'bone/ivory' industry seen in the numerous inlays recovered from Chrysolakkos and elsewhere in the Mallia complex. The use of bone need not reflect anything so dramatic as a decline in ivory supplies but simply that for small inlays, bone was a perfectly adequate material. Squares, strips and even plano-convex inlays can all be produced from bone provided the material is handled properly. Nor is the presence of cancellous bone on the underside a disadvantage for inlays. The use of another local material, shell, for some of the small plaques at Mallia is also worth remembering.

Mallia and Phaistos also provide some of the scanty information we have regarding the use of bone tools during the first palace period. From those items which have been published it would be irresponsible to make assertions regarding the nature of the Cretan bone industry of the period. Recognisable types such as ribs (Type 12) and split metapodials (Types 5 and possibly 4) do exist but the numbers of items are too small and the types too common to offer major insights into the manufacture and use of bone tools in Middle Minoan Crete. Most important is merely their existence, pointing to the continued presence of a traditional bone industry on the island, notwithstanding the gaps of the pre-palatial period. Moreover these implements are all from areas in and around the palaces where one might have expected an early 'takeover' of bronze implements had they been universally suitable.

Little more can be said about the traditional bone industry during the second palace period, except that it seems to have continued. A few bone tools are known from MMIII/LMI contexts at such sites as Palaikastro, Tylissos, Mallia and Knossos (Royal Road, Warren).[6] Once again they simply demonstrate that bone had not been entirely replaced as a medium for making tools. Still less is known about the use of bone tools in the post-palatial period. Since so much of our evidence for these periods is derived from palatial or burial contexts it is hardly surprising that our information about the bone industry at this time is so slight.

By the second palace period we may detect a shift in the 'bone/ivory' industry to the ivory industry proper. However, small objects, especially inlays still seem to be made in bone if the identifications by Evans of the material used for the 'buds', 'fish' and 'bracelets' from the palace are correct.[7] Some of the Mallia plaques of MMIII/LMI date are also described as bone. It may be that ivory was still reserved for those objects which demanded greater versatility in shape or which were intended as fine 'objets d'art'. Nonetheless this shift into an industry based almost exclusively on the use of ivory had occured by the LMIb period as evidenced by the Royal Road deposit at Knossos. Virtually all the extant objects, however small, are made from ivory rather than bone.

The value of ivory even for small objects is two-fold. In the case of plaques, a very high sheen may be obtained by careful polishing, unlike bone, which may be polished but will never display the same homogeneity of colour and texture. Further, the ability of free-carving in ivory allowed one type of small object to be manufactured in this material which would be difficult in bone. This is Type 11d, the hooked or 'shepherd's crook' pin, one of the few cases where it seems a metal form was taken over in bone/ivory rather than the opposite.[8] The hooked pins seem to be a distinctive Minoan fashion and occur in a variety of metals. I know of only one example in bone and as is clear from the illustration (pl. 75b) the size of the hook is severely limited. The intact example in ivory (pl. 75a) shows how bold the hook could be given freedom in shape by the raw material.

The ivory industry of the second palace period does not confine itself to the manufacture of small items and is best known for larger pieces displaying both skill in carving and inventiveness of design. The acrobats, in particular, are fine examples of the advances in handling the material, both in the rendering of physical details and the use of mortise and tenon for joining up the various segments. Three-dimensional carving in ivory up to this time had been limited.[9] The pre-palatial bone/ivory figurines are hardly more than cut-outs and most of our first palace period material is restricted to two-dimensional inlay work. Yet the quality of the ivory figures is so high that one must suppose that skills and techniques had been perfected on other materials, especially wood, which have now been lost.

The origins of relief carving such as seen in the Palaikastro bird plaque or the lion and griffin from the South House are not much clearer (62b: 3, 6).[10] They seem to have few antecedents although simple grooves and incision had been used on small inlays earlier. Various other objects, principally attachments in relief (Type 61) begin to appear in MMIII/LMI contexts. These include sacral knots, double axes, the dove from the Royal Road (61: 21), the shells and butterfly from Zakro (61: 13, 34). The Palaikastro comb (34b: 12) is of LMIb date while the Katsambas pyxis which is dated by context to LMIIIa may on stylistic grounds be assigned to the LMIb period.[11] (see below p. 311). It is significant that all the ivory types mentioned above, barring the acrobat statuettes, continued through the late bronze age becoming familiar 'Mycenaean types'.

Following the LMIb destructions, ivory still occurs on the island principally in grave goods. The tombs from Archanes have provided a particularly rich source of LMIII material but fine ivories are also known from Zapher Papoura, Kalyvia and Ayia Triada. Inlays, attachments (especially figure-of-eight) and combs all occur and fine relief plaques have been discovered at Archanes.

Mirror handles (Type 44) of which several are known from the island seem to be new in the LMIII period but whether the inspiration for this form was mainland rather than local is difficult to say.

On the whole the difficulty with the ivory industry on Crete in this period is connected with the wider controversies surrounding the presence of mainlanders on the island and their impact on the Cretan culture which may have been weakened by the eruption of Thera. If we are correct in believing that the principal forms of the LMIIIa period, namely attachments and objects bearing relief decoration such as combs, plaques and pyxides had appeared in purely Minoan, pre-destruction contexts, then continuity in the craft is suggested.[12] Much of the carving of the LMIII period may have been done by Cretan craftsmen even if their work was no longer principally for Cretans. These questions will be considered from another angle in our discussion of the ivory industry of the mainland (below p. 311).

THE MAINLAND

While our evidence for the bone industry throughout the bronze age on Crete is poor that for the mainland is very much better owing to the nature of sites excavated. Although the palaces and their burials, may overshadow settlement evidence for the Mycenaean period, for the earlier part of the bronze age we have a number of settlements which have yielded bone tools. That said, it must be recognised that the value of much of the published material from such settlements is limited by the quality of older publications. Worked bone is published, but rarely in a manner which allows a detailed study of the individual pieces, much less an integrated approach to the role of the bone industries on the mainland. For that we must rely heavily on Lerna and it may be some years before an adequate study of that bone industry can be produced.[13]

The areas of continuity and difference between the traditional bone industries of the neolithic period and those of the early bronze age cannot yet be quantified. Lerna has produced a good collection of neolithic bone implements (figs.124-5) but the gap between the end of the neolithic and the first bronze age settlement (EHII) prevents us from pin-pointing the exact time of the changes. This is further impeded by the nature of the Lerna III evidence as a whole (p. 273). Asea has produced tools of Neolithic - EH date although the manner of publication prevents any clear appreciation of the industries.[14] The Franchthi evidence ends before the beginning of the bronze age, most unfortunate in view of the large quantities of worked bone recovered from that site and the excellent study of it which is in progress.[15]

Some similarities do exist between the industries of the Lerna neolithic and of succeeding periods but on the whole these are fairly superficial and likely to be found in bone industries of widely divergent geographical areas as well, since they are founded on the natural features and limitations of the bones available. Various pointed objects are made from metapodials during Lerna I and II but for the most part they are much shorter and more heavily trimmed than the later implements made on the same bones. (see fig. 124). As always one must remember that the 'type' of tool ultimately rests on the function which it is to perform. The activities which required bone tools during the neolithic may not always have been the same during the bronze age.

For the EHI period we have virtually no information, a few examples from the more recent excavations at Eutresis only. In EHII the number of tools recovered increases owing to the number of EHII contexts investigated. Pointed objects, many unidentifiable in poor photographs, and some blunts occur. Rib bone tools (Type 12) are known, but the designation of 'EBA or EH type' for these is regrettable.[16] Their greatest known concentration may well be of this period but bone tools do not respect pottery-based chronologies. We must never be tempted into 'dating' a tool solely by its appearance since that is determined by the natural shape of the raw material and intended function, about which we may know nothing.

The evidence of the worked bone does little to ease the general problems surrounding the cultural breaks seen either at the end of EHII, as at Lerna, but possibly at the end of EHIII on other sites.[17] The amount of material is too small and the contexts of individual pieces too imprecise at all sites but Lerna, to determine whether a major change in bone working techniques and the use of bone tools for various activities indeed took place at this time. As we have noted (pp. 273 ff) the evidence for an increase and change in the bone industry between Lerna III and IV is shaky although the case for some continuity between IV and V is stronger.

Bone pins, of course, are more distinctive than tools and may be linked to certain periods or cultures with slightly more ease than ordinary bone tools. Nonetheless their value as indicators of cultural change must be limited since they may be the result of native inspiration, increased skills in working a material, or even the adoption of fashions practiced by other peoples with whom contact has been made. In terms of the problems surrounding the EHII/III - MH cultural changes on the Greek mainland, the pins are but a minor piece in the archaeological jig-saw. Plain pins go back even into the neolithic period and do occur in EHII contexts, but the tradition of decorating the heads, first, it seems in simple shapes (11b) appears to begin during the EHIII period. In fact, most examples of that date come from Lerna.[18] Elsewhere they occur chiefly in MH contexts. Moreover, at Lerna it is very difficult to be certain that the simple pins were introduced at the very beginning of Lerna IV and since the principal concentration of these and the decorated examples (11c) occur in period V, it seems likely that these types were actually developed at Lerna. That is, the bone pin industry does not seem to have been introduced fully-fledged after the destructions. Without the supporting evidence of new architectural forms, pottery styles and techniques, burials and the like of the EHIII/MH period, the decorated bone pin alone would be insufficient to indicate new inhabitants.

From a more positive point of view, the introduction of decorated bone pins does indicate skills, increasing with time, in the production of non-functional items in bone. In some ways this is akin to the development of the bone/ivory industry on Crete with its attention to seals and other small objects of bone and ivory during the pre-palatial and first palace periods. On the mainland, however, there were no real supplies of ivory which might have encouraged greater inventiveness in terms of shapes and objects until much later. While important, the recent finds from Thebes (p. 43) are exceptional and cannot be taken as early evidence of an 'ivory industry' on the mainland. The Lerna examples also mentioned above (p. 49) are likely to be imports.

The rare attempts at decorative bone working apart from pins are few and rather late. The Asine bone sheath or plaque (67: 1) and the strips from Eleusis and Eutresis (57a: 1, 56c: 1) are the only examples of such work before the shaft graves. The Thebes plaque, although of ivory, may be placed in the same class (57a: 20). The same distinction between a traditional bone industry and a bone/ivory industry made for Crete, seems also to have occurred on the mainland, but the latter was slower in developing.

By the time of the shaft graves there is at last, on the mainland, a reasonable amount of ivory and a little more variety in the bone/ivory industry. In the earliest graves of Circle B there is however very little in these materials at all.[19] A bone pin was found in shaft grave Sigma. It has a head decorated with a series of grooves and toruses, common in the Mycenaean period. The grave was disturbed during the construction of Lambda, so the pin cannot be dated securely. Grave Zeta has produced a badly decayed pommel in ivory (43: 25) but this grave also was disturbed, in one of the attempts to cut Omicron. No objects in either material were recovered from Eta or Theta.

A few more items in bone/ivory occur from graves of the middle phase, notably sword pommels (43: 26-27) from graves Iota and Lambda; fragments of a knife handle (38: 7) and a bone strip said to be decorated with incision (NC) from Iota. Also from this grave are the problematical bone 'sceptre mounts' (67: 11) similar to some from Bush Barrow, Wiltshire. The resemblance is almost certainly coincidental.[20]

It is not until the later graves of Circle B that the main sequence of bone/ivory remains begins. From grave Mu come five bone pins (11c: 86, 11e: 22) with heads decorated with grooves and toruses in the manner that becomes standard in Mycenaean pins. Badly decayed pommels (43: 22-24, 29) were found in graves Gamma, Delta and Omicron. Plaques (Type 56), rectangular, lozenge-shaped and discs with holes occur in the later phase graves Alpha and Gamma. These are also known from later Mycenaean contexts. Also worth mention is the fragment of a large plaque with spirals in relief decoration (ANM 9570).

It is difficult to know whether this plaque or any other goods of ivory in Circle B were imported ready made. Most of the items are quite simple in form and design and could almost certainly have been produced by the existing local bone/ivory industry. The ivory pommels are a new item in the repertoire but smaller knobs of bone or antler were being produced on the mainland during the MH period (42a: 1, 3) so there is no real need to look to Crete for the manufacture of the ivory examples. The comb (34c: 3) is also something new, but it is of the 'peigne à corne' type which has no parallels on Crete.

From the early graves of Circle A which overlap with those of Circle B come only a pommel and some fragments of strips (Grave VI) and numerous ivory fragments which Poursat has tentatively suggested may be a vase (70: 37). Such items are extremely rare, but another possible example was discovered at Prosymna.[21]

As might be expected graves IV and V have yielded most of the ivories of this date. A number are accoutrements of weapons such as pommels, hilt-plates and knife handles. Boar's tusk helmet plaques and other attachments of boar's tusk possibly plume holders have also been recovered. Most other items are a series of inlay strips and squares in bone, ivory and unusually boar's tusk. Also worth mentioning are the partially worked boar's tusks and fragment of partially worked ivory (74: 36) found in Grave V suggesting that the materials themselves had intrinsic value not only when decorated.

The use of bone and boar's tusk for inlays (e.g. 59: 20-21) indicates that ivory may still not have widely used at this time and seems to parallel the slightly earlier situation on Crete. There is, however, no reason to suppose that any of these items were not produced by the local industry even though some of the raw material was imported. The inlays do have considerable similarity to those from earlier and contemporary Cretan contexts but this may merely indicate mainland copying of Minoan forms rather than ready-made imports. The bone buttons with gold leaf covering on the other hand, are almost certainly native mainland inventions and products. Flat discs of bone or ivory with decoration, usually simple concentric circles and dots, do occur both on Crete and elsewhere in the Aegean but nothing at all like the Circle A discs has been recovered apart from the Kakovatos 'buttons' (49b: 2) and the new example from Ayia Irini (49b: 1, above p. 281). The lozenge-shaped buttons with similar incised decoration are unparalleled.

The remaining material from the shaft graves consists of an ivory hair comb with gold-leaf covered back and a pyxis.[22]

The latter is unusual as it bears incised rather than relief decoration as is the norm for pyxides and most later Mycenaean carving. The item comes from the latest grave (I) of LHI-IIa date and might therefore post-date the Katsambas pyxis. It is of the thin-walled variety which may have served as covers for pyxides in other materials.[23] The incised pyxis from Ayia Irini, we may recall, was of Kea VII (LMIb/LHII) date.

Apart from these two items which have few parallels and uncertain forerunners the picture of the bone/ivory industry producing the objects in these materials for the shaft graves is fairly clear. The range of types is rather restricted and in most cases either local antecedents can be detected or local invention assumed. In a few cases the impetus for the forms might have come from Crete but rarely is there much indication of direct imports. On the whole this may seem rather surprising in view of the wealth of imported material found in the richer graves.

Before considering the later developments of the bone/ivory industry during the Mycenaean period, it is worth noting our evidence for the continuity of a traditional bone industry on the mainland during the LBA. On the whole, our information is rather poor, dependant as it is on the excavation of well-stratified settlement sites. A few examples of bone implements come from LH contexts at Eutresis, Asine and Malthi, but with the end of the Lerna sequence (above p. 278) once again we are left with large gaps in terms of distribution of types. Nonetheless, bone tools did continue to be used throughout the period as did implements in antler. The finds in that material at the Citadel House have already been discussed (above p. 287) and the existence of some bone tools on that site may be recalled. Although few in number and mostly unclassifiable as to type, they do indicate that even at the height of Mycenaean culture, ordinary bone tools had a place in certain occupations.

It is however, the bone/ivory industry which comes to the fore during the Mycenaean period and soon seems to adopt ivory in preference to local materials for most classes of objects. Pins are the notable exception and it is possible that bone may have been a more suitable medium, less liable to fracture. A great many items come from burials although the principal palaces have also yielded much fine ivory work. Unfortunately a number of our sources, especially those excavated before the war, cannot be dated with great precision, so that many of our Mycenaean ivories must be accepted simply as Late Helladic.

Objects dated to the earlier Mycenaean period (LHII-IIIa) come from the tholos tombs at Kakovatos, Routsi and Thorikos, and at Mycenae from the 'Prehistoric Cemetery', the tomb of Aegisthus as well as some chamber tombs.[24] Although the number of items is not great it appears that all the major types current during the later Mycenaean period had become firmly established. These forms include relief plaques, pyxides, decorated combs and relief attachments. Most seem to have parallels in second palace period contexts on Crete. The dating of objects from these Cretan contexts thus takes on a major significance for the origins of the Mycenaean ivory industry. For if the Cretan examples (South House plaque, Katsambas pyxis, Palaikastro comb) are indeed correctly assigned to LMIb date, they must at least be contemporary with the earliest known mainland examples and may even precede them.[25] This could mean that the inspiration for the great works of the Mycenaean ivory industry was Cretan and that some of the examples from earlier mainland contexts might even be the work of Cretan rather than mainland ivory carvers. Such an interpretation would be yet another variation on the conventional theme of Cretan artists working for the mainland which has dominated much of our picture of Minoan-Mycenaean art.

Not only is this view difficult to prove for ivory working but an entirely opposite interpretation may be correct. Clearly, since there is no long tradition for these forms in Crete before LMIb it is possible that they are in fact the work of Mycenaean artists. This would indicate that the origins of Mycenaean ivory carving were native inventions. Or, as Poursat concludes his major study of Mycenaean ivories:[26]

> A sa naissance, l'art des ivoires (mycéniens) est un art sans traditions: il ne derive ni de l'art des ivoires minoens ni des groupes orientaux.

Poursat reaches his conclusions after a detailed study of both form and style of Mycenaean ivories and as such they must be regarded with great respect. It is certainly regrettable that more secure dating for the LMIb/LHII pieces cannot be established.

It is unlikely that we shall be able to prove conclusively the origins of Mycenaean ivories, at present. However, it might be worth recalling that Crete had a far longer tradition in bone/ivory working than the mainland and more importantly had, by the second palace period, begun to experiment in various new forms using ivory. By contrast, on the mainland, even by the time of Grave Circle A the repertoire of forms and motifs was still extremely limited.

Whatever their origins may be, Poursat is certainly correct in stating that by the LHIIIa period the whole range had been established. Thereafter it is difficult to discover new forms or even styles of decoration. A few of the earlier types such as 'peignes à corne' (Type 34c) and rosettes or waz-lilies with relief decoration (Type 60) may even die out. With the LHIIIb period we gain evidence for ivory working occurring in the vicinity of the palaces, especially Mycenae. These workshops together with the fine finished pieces demonstrate that ivory carving had become one of the major Mycenaean crafts.

Our evidence for the LHIIIc period is rather scant whether for the traditional bone industry or for the ivory industry. Ivory remains still occur although quantities seem reduced in real terms. As mentioned above many of the ivory fragments both waste and partially worked from the Citadel House, Mycenae may well belong to the LHIIIb period although dated by context to 'LHIIIc and earlier'. The finds of the Unterburg at Tiryns and Perati seem to indicate that a very limited range of forms was being produced. Combs, pins and a few inlays are the principal items. It is not certain whether the Perati pins are all ivory; certainly the combs from these sites together with those of possible LHIIIc date from Achaia (34a: 9, 35) are all plain, undecorated specimens with simple division into registers.[27] Finally, without the ready supplies of large quantities of the raw material the ivory industry must have subsided once more into a bone/ivory industry, producing only small goods in a limited range, dictated by the type of raw materials available.

THE CYCLADES

Until recently, the evidence for a bone or ivory industry in the Cyclades was so slight that it was almost possible to believe that none existed on the islands. The bone tubes and bird pins (11c: 13) from Syros have, of course, long been known and there are a few tools published from Phylakopi and Kythera.[28] However, until the Kea material became available there was little to support the notion that the materials studied here played any significant role in the cultures of the Cyclades during the bronze age.

We are fortunate in having the fine drawings of worked bone from the late neolithic settlement at Saliagos as an indicator not only of the existence of bone working on the islands but also for the clear parallels they provide for certain tool types not otherwise encountered in published material.[29] These do not indicate any links between sites possessing such types, merely illustrate that given a thorough examination of the worked bone and publication of high quality drawings, our knowledge of worked bone in the Aegean would be considerably greater than it is today. Worked bone in small amounts was also recovered from the neolithic site of Kephala on the island of Kea.[30]

For the EBA our picture is almost blank. Apart from the few examples of bone tools from Ayia Irini (above p. 279), bone tubes constitute the principal remains in that material. The reason for this dearth of worked bone may however be explained by the nature of our evidence for Cycladic culture at this period. By far the majority of our information comes from burial rather than settlement material. As observed elsewhere, the absence of worked bone, especially tools, from burials is no indicator of their absence from the domestic tool kit. Bone tubes, whose purpose is still debated, could well fall into that hazy category of functional-cum-decorative items. That is, they might be regarded as akin to seals or pins, in having an underlying practical purpose yet were also of decorative nature. This might account for their presence in burial contexts.

There are, however, other factors which might also account for the apparent 'absence' of a bone industry on the islands not only during the EBA but later. The first of these is the question of obsidian. Obsidian, especially Melian, was clearly a raw material near at hand.[31] It was plentiful. Could it not have been used in place of bone? To determine this requires an understanding not only of the purpose of bone tools but also those of obsidian. Without such expertise observations must remain tentative. However, it seems highly unlikely, that all functions, particularly those of piercing through skins and cloths could be performed by obsidian implements. Scraping, cleaning skins and polishing, in addition to ordinary cutting would be more likely areas for obsidian to replace bone. It may be remembered that stone, especially obsidian which is friable, lacks those very qualities of bone, namely flexibility and resilence mentioned at the outset of this study. It is interesting therefore to find bone blunt implements on both Saliagos and Ayia Irini indicating that for some activities bone may have been as good as, if not better than stone.

The durability of obsidian may have rather more to do with its apparent predominance over bone in the Cyclades. Like sherds, it is virtually indestructible, while bone may, if subjected to the elements, be eroded. Indeed, erosion or soil conditions might be an added factor in our lack of bone tools.

Finally we may consider the question of availability of materials. While we have information regarding the species present on Ayia Irini, Thera and Phylakopi, until the faunal reports are finally published we do not yet know to what extent meat as opposed to dairy or marine sources formed the basis for the diet. Since the production of bone tools is largely bound up with the availability of fresh animal bone we might expect few bone tools from sites which slaughtered animals only occasionally for their meat. Those sites exploiting animals on a more systematic basis for their protein would very likely have greater supplies of bone for tool working. In his repliminary report on the faunal remains from Thera, Gamble points out that, 'Meat was (probably) an occasional resource butchered by the household rather than an economic staple . . '[32]

All of these factors might have influenced the Cycladic bone industry to some extent and more detailed work with the remains of our three principal settlements will be required before definite conclusions can be reached. Nonetheless the problem of sampling will probably remain the largest single element in the difficulties of reconstructing the bone industries of the Cyclades, especially in the earlier part of the bronze age. Further excavations, particularly of settlements, such as the current investigations at Koukounara (Paros) will certainly help to build up a more balanced picture.[33]

On the Cycladic islands we may also see the development of a bone/ivory industry producing objects of not strictly utilitarian nature. The evidence from both Phylakopi and Ayia Irini now indicates that unworked ivory was reaching the islands, probably from the MBA onwards. The amounts may never have been large which could account for no really distinctive Cycladic style of ivory work emerging. While it is dangerous to argue from such a small collection of items as we have from Phylakopi, Thera and Ayia Irini it seems that even if manufactured locally, objects were of types current elsewhere in the Aegean at the time, whether on the mainland or Crete. This is further reinforced by the use of local materials on Kea to produce the small pyxis and figure-of-eight shield. Other objects such as the rosette from Thera (58: 14), the finial from Phylakopi (61: 32) and the pyxis and button from Ayia Irini are all probably imports.[34] This accords generally with our picture of these Cycladic islands during the LBA, although more detailed information regarding the finds from Thera as well as later contexts (period VIII) at Ayia Irini will be welcome.

There is, however, no reason to believe that the bone/ivory industries of the Cyclades were merely producing provincial copies of Cretan and mainland products or relying on ready made imports. Although the number of items is few, it seems that objects in a purely local style were being produced throughout the bronze age. The Kea pins with herringbone decoration are good examples, while the use of shell, perhaps in place of ivory for carving in the round may similarly be a local feature.

THE NORTH-EAST AEGEAN

By contrast to the other areas of the Aegean, the island sites of the North-east Aegean present a much more unified picture of the traditional bone industry. Once again it is the nature of the sites themselves from this area which dictates the evidence available for our study of worked bone. The sites included in this study, Thermi, Poliochni, and Emborio together with the comparative site Troy are all settlement sites with a number of successive strata spanning the EBA. In fact their origins, contemporary with Troy I, are earlier than the EBA in Greece.[35]

All the sites including the later excavations at Troy have yielded good collections of bone tools, in most cases of exceptional quantities. The reasons for this may be mixed. First, there is the size of the settlements themselves and the area excavated. Elsewhere in the Aegean there a few sites of pure EBA date and the amount of EBA material that has been recovered is restricted by later habitations. Secondly, the very fact that they are settlements and not burials, which provide so much of our evidence for Crete or the Cyclades in the EBA is advantageous in the recovery of worked bone. Nor have excavators in this area been occupied with the enormous problems surrounding the investigation of palace sites. Finally we may simply be fortunate in having had a series of conscientious directors intent on the presentation of a comprehensive account of the activities of their sites, of which worked bone was only one. It may be added that although Schliemann's Trojan material is not included in our comparative references, his illustrations of worked bone for that site are finer than many which are produced today.[36]

Thus, the nature of these sites and manner of publication have presented us with enormous quantities of worked bone. If one includes the objects from the Cincinnati excavations there are some 3000 pieces to be considered. But does this indicate that the bone industry of the North-east Aegean was more flourishing than those of other areas? Did the inhabitants rely on bone tools more than other implements for their domestic activities? It would be futile to pretend that a wholly conclusive answer to these questions can be given. Nevertheless we must attempt to evaluate the existing evidence with such problems in mind.

First there is the question of absolute numbers. As indicated elsewhere and stressed with respect to the distribution tables in the catalogue, numbers of bone tools recovered from various regions or even various levels of the same site have little value unless one can control the basis for comparison. It is useless to compare the numbers of tools recovered from a level of a site exposed over the area of half a hectare against those found in a small trench revealing a portion of one room only. Without a basis for comparing fixed amounts of tools, then, conclusions regarding relative frequency of tools in the various areas of the Aegean must remain highly tentative. Nonetheless, my own feeling is that bone tools were no more common, or perhaps only a little more so, than elsewhere in the Aegean during the bronze age.

A slightly less speculative approach to the problem may be through types of tools represented. Although we can rarely assign specific function to tools and must recognise that the same types of tool need not always imply identical function, it is worth examining their distribution in the North-east Aegean and elsewhere. As seen at Thermi, rib bones (Type 12) constitute the single largest group, followed closely by tools on splinters of long bones (Type 5). At Poliochni (using only the illustrated material) ribs, followed by split long bones (Type 4 and 5) are most common and a similar picture is seen at Troy. This, although the numbers are scarcely sufficient for analysis, is the general impression from EBA Kea and Lerna III. Type 7 (double-ended) and Type 9 (pin-like) are all present at Thermi, Poliochni, Troy and Lerna as is Type 3 made from pig fibulae. Type 1 tools present slightly more problems in that the Thermi examples seem to have been lost (above p. 270) and one cannot be entirely sure what all the items included in Lamb's type 2 pointed gouges really looked like. The use of sheep/goat long bones for Type 1 implements is nonetheless attested at all the sites including Emborio and also at Lerna, but not, it seems until EHIII. Not known on the mainland is the use of smaller leg bones including hare tibiae to make fine slender examples of the type.[37]

The range of blunt implements also seems fairly similar to that encountered elsewhere, especially at Lerna IV. Poliochni has not produced any Type 19-20 blunts on ribs, but the problems of recovering this type has been noted elsewhere.

Among the other objects which are found on both mainland and in the North-east Aegean are pins with simple and decorated heads although it may be recalled that the mainland sequence seems to begin rather later (EHIII/MH) and there are no parallels for the finest Thermi products anywhere in the Aegean. The Poliochni pins are more sober in comparison and offer good parallels to the simpler shapes known from Lerna during periods IV and V.

'Weights' or 'pommels' (Type 46 and 48) are attested in both areas as are plain tubes, although Poliochni is unusual in having an example of the 'Cycladic type' with incised herringbone and zig-zag decoration. Could this single piece perhaps have a direct Cycladic origin? Finally worth mentioning is the use of small leg bones, including sheep/goat metapodials as handles for bronze awls. No examples with their bronze implements intact are preserved from such early contexts on the mainland, but that is likely to be chance, since bronze awls did clearly exist and portions of long bones such as are known from a number of EBA contexts make ideal handles. The example said to be 'eneolithic' from Phaistos might also be mentioned here.

We can, therefore, see that there are a number of similar types of tools current both in the North-east Aegean, mainland and probably Cyclades during the EBA. More significant than basic shape of tools is also their finished appearance which tends to suggest similarity in methods of manufacture. Given the restriction on the basic raw material one must be careful not to push the evidence of similarities too far. Nevertheless, cautious observations about the likelihood of similar activities and methods of manufacture may be possible.

It is true that a few types of bone tools exist in the North-east Aegean which are rarely found elsewhere. Bladed implements (Types 30, 31) are more common on those sites, although it is possible that serrated tools (Type 32) took their place on the mainland and islands. The idol-headed variety of Poliochni (Type 31b) may well be a local fashion since the shape of the 'head' does not affect the nature of the working end of the tool. However, if the North-east Aegean bone industry were radically different from that elsewhere in the Aegean one would expect a different range of types with far less overlap than actually exists. It seems likely, therefore, that there is some degree of unity between the industries of the North-east Aegean and elsewhere. Indeed, that region with its good series of worked bone in large numbers for the EBA may give us a truer picture of the Aegean bone industries at that time than the evidence from Crete, the mainland and Cyclades can provide.

What is lacking from the North-east Aegean is good evidence for what we have called elsewhere the 'bone/ivory' industry. Apart from a few pieces from Troy, ivory remains are non-existent in the area. Nor is there much experimentation in the use of bone for decorative items apart from the pins. From Poliochni we have only two bone plaques with incised concentric circles (57a: 15-16) and a small bone figurine (63: 12). This is a similar situation to that of the MH period on the mainland where virtually the only essays into a non-functional use of bone were pins with only a few examples of bone strips or inlays. There, further development of the industry had to wait until the introduction of ivory at the time of the shaft graves. In the North-east Aegean our sites end before the introduction of this material except at Troy where a bone/ivory industry can be seen to develop on a small scale.

CONCLUSIONS

The preceding summary of the evidence indicates that throughout the Aegean region certain common features in bone and ivory working may be observed. The features are not always contemporaneous but may reflect differing stages of social or economic development in the various areas.

All areas seem to have sustained traditional bone industries which continued through the bronze age. Whether there was ever a significant reduction in the use of bone tools cannot be determined given our present evidence and methods of dealing with it. Certainly the industries continued to evolve and produce new types even at the height of the bronze age. On the mainland and the islands, antler supplemented the use of bone even during the LBA.

On the whole the traditional bone industries, producing purely functional objects, present a fairly unified picture throughout the Aegean, apart from a few regional variations. In more decorative items, regional peculiarities are more noticeable.

Some of these small objects, such as the fine bone pins of the North-east Aegean in the EBA or of the mainland during the MH period, may have required specialist skills in their manufacture.

The impact of ivory on these industries seems to have been twofold. First it stimulated experimentation in existing forms and the development of new forms. The Cretan seals best exemplify this. The second aspect, though more difficult to prove, hinges on the physical properties of ivory and its status as an import. It seems likely that its introduction may have encouraged specialisation in manufacture.

The continued use of locally available materials for non-utilitarian objects even after the introduction of ivory in each region has led to the term "bone/ivory industry". Availability of ivory and its 'cost' almost certainly affected selection of materials. Some areas such as the Cyclades probably never supported a fully developed ivory industry. On the mainland the use of bone/ivory at the time of the shaft graves gave way quite quickly to the ivory industry of the Mycenaean period, doubtless because of the ever-increasing supply of the precious raw material.

By the second palace period on Crete or the LHII/IIIa period on the mainland, the use of local materials instead of ivory almost ceases. Only in the case of pins does bone apparently continue to be important. Otherwise the local materials are relegated to the production of utilitarian objects.

The considerable quantities of ivory entering the Aegean from roughly 1500-1200 clearly allowed ivory carving to develop into an important industry demanding specialised skills and artisans. The precious nature of the materials, the quantities involved and skills of workers all contributed to ivory carving becoming a palace industry. By the height of the Mycenaean period, most, if not all production, was centred on the palaces. The collapse of this highly centralised system at the end of the bronze age meant that trade in the commodity and expertise in its working were lost.

NOTES TO CHAPTER I

1 For an extant group of material which was never published see Appendix IIa (Objects of Unknown Provenance from Sir Arthur Evans' excavations at Knossos). For material which cannot be located or may be completely lost see Chapter IX note 14.

2 J.-C. Poursat, Catalogue des ivoires mycéniens du Musée National d'Athènes (Paris, 1977); idem, Les ivoires mycéniens (Paris 1977).

3 R.G.D. Evely, 'Minoan Crafts: Tools and Techniques' (D. Phil. thesis, Oxford, 1979).

4 I. Sakellarakis, To elephantódonto kai i katergasía tou sta mykinaïka khronia (Athens, 1979).

NOTES TO CHAPTER II

1 I.W. Cornwall, Bones for the Archaeologist (London, 1968), p. 204 ff; R.E. Chaplin, The Study of Animal Bones from Archaeological Sites (London, 1971), p. 12 ff.

2 Chaplin, op. cit. (note 1), p. 12.

3 ibid., fig. 3 for an excellent illustration of the location of cancellous bone.

4 The term metapodials is used when it is not possible or necessary to distinguish between the metacarpals and metatarsals. Other technical terms will be defined in the Glossary (Vol. II).

5 I am indebted to Dr. G. Bailey of the Department of Archaeology and Anthropology, University of Cambridge, for permission to draw specimens in the Bone Room of that department. I have also made drawings from the faunal collections of the Passmore Edwards Museum, London Borough of Newham, and thank the Assistant Curator of Biology, Colin Plant, for his assistance. For bones not illustrated here see figures in Cornwall, op. cit. (note 1) or in E. Schmid, Atlas of Animal Bones (Knochenatlas) (Amsterdam, 1972).

6 Moreover there are indications that on some sites animal protein itself may have been an occasional item in the diet. See further Chapter IX, p. 316, and C. Gamble, 'The Bronze Age Animal Economy from Akrotiri: A Preliminary Analysis'. Thera and the Aegean World (London, 1978), Vol. I, p. 747.

7 Progress is being made on differentiating between these species; see, for example: J. Boessneck, 'Osteological Differences between Sheep (Ovis aries L.) and Goat (Capra hircus L.)', in Science in Archaeology, ed. D. Brothwell and E.S. Higgs (London, 1969), p. 331 ff. For the purposes of this study I follow standard practice and the identifications of worked bone by faunal analysts in using the term sheep/goat.

8 Fish spines are frequently encountered in worked bone lots. They have a natural patina which might be suggestive of wear, but rarely have I detected traces of such, either with the naked eye or under x 15 or x 30 magnifications. We cannot, however, be absolutely certain that they were never used. At Ayia Irini they have been retained, with reservations, under the heading of worked bone (See Appendix IVa, Kea Type XIII). Only a few are included in the Catalogue of the present study (Type 14).

9 The faunal analysts concerned are N.-G. Gejvall for Troy and Lerna and J.P. Coy for Ayia Irini. Some of the worked bone from Mr. Hood's excavations on the Royal Road, Knossos, is said to have been identified by the late E.S. Higgs. Elsewhere I have had to rely on my own experience for identification for bones used. See also note 34 below for Thermi.

10 I am extremely grateful to Professor J.L. Caskey for permission to use the Lerna collection for this study and to other members of the Lerna team, Dr. C. Zerner and Dr. M.H. Wiencke, as well as the Argos Museum guards for assistance during my six week stay session in 1979. My thanks also to Professor Caskey for permission to use the interesting collection of worked bone, antler and ivory from his excavations at Ayia Irini. Members of that team, especially Dr. E.T. Blackburn, Professor J.L. Davis and Dr. E.V. Schofield have been most helpful.

11 E.C. Banks, 'The Early and Middle Helladic Small Objects from Lerna' (University of Cincinnati dissertation, 1967; available from University Microfilms. Ann Arbor and London). The chapter on bone objects begins on p. 263. See Appendix IVb and Chapter VI for a new typology of the Lerna bone which I have prepared at the request of Professor Caskey.

12 J.L. Caskey, pers. comm. July 1979 and subsequently. It should be noted that the work on Lerna presented in the Catalogue and elsewhere in this study is essentially my own. However, I should like to add that the existence of Banks' catalogue has in some respects facilitated my work. Further discussion of Banks' typology and approach to the Lerna worked bone appears below especially p. 200 ff and 271 ff.

13 Another possibility for the manufacture of flat bone discs would be scapulae of cattle although such a use is not attested for the Aegean. For experimental reproduction of bone discs see: M. Newcomer, 'Experiments in upper palaeolithic bone work', in Colloque II. pp. 296-97 fig. 4.

14 Full definitions of these and other types may be found in Chapter VII and on the introductory pages to each type in the Catalogue. Occasionally the bones of juveniles are used (e.g. 1a: 22, 28, 43) which can be detected by the fact that the epiphyses are not fused to the shaft (diaphysis).

15 Cornwall, op. cit. (note 1), p. 154 ff., fig. 44 (d) and p. 178 ff., fig. 50 (e). Sheep/goat are not illustrated but the principal of fusion shown in the cattle metapodials is the same. See also my figs. 3 and 4.

16 My thanks to Miss K.J. Scott of the Garrod Laboratory, Department of Archaeology and Anthropology, University of Cambridge, for discussions on this and other issues pertaining to animal bones. It is unlikely that the selection of metacarpals over metatarsals is unique at Lerna or even the Aegean. Miss Scott informs me that metacarpals are fashioned in a similar way on South African prehistoric sites.

17 Cornwall, op. cit. (not 1), p. 144 and 157.

18 I am grateful to Sebastian Payne and Katharine Scott for confirming this identification. In Mr. Payne's opinion the bone was from a mature animal, possibly eight or nine years old. However, as the size of cattle bones varies greatly, some caution must be exercised before settling for such an age (pers. comm. Miss Scott).

19 Some of these ring-shaped seals may have been made from one of the distal condyles of a metapodial, rather than from a transverse section of the shaft. See below, Chapter III p. 82 and Appendix III.

20 I have seen a large number of cattle ulnas among the worked bone lots from Professor J.D. Evans' 1969 excavations of Neolithic deposits at Knossos. Many have their lower end broken off and as the shaft and epiphysis show no signs of working they may never have been used at all.

21 Also suggested to me by Sebastian Payne in conversation. Evidence from an unpublished site which I am not at liberty to discuss may provide useful support for the theory that they were employed as weights.

22 Banks has also put forward this suggestion. Banks, op. cit. (note 11), p. 369. See also comments on Types 19 and 20 in Chapter VII and the introductory pages to these types in the Catalogue for comparative material.

23 For proportion of pigs to other species at Ayia Irini and other sites see Gamble, op. cit. (note 6), p. 752 fig. 2.

24 Cornwall, op. cit. (note 1), p. 166.

25 It may not, of course, have been an omission by Gejvall but caused by inconsistencies in editing. For example we read 'front leg bone of bos' to describe what in that case is clearly a cattle ulna (Blegen II, p. 211, fig. 149 no. 32-381).

26 My thanks to M.S.F. Hood who allowed me to study his text and drawings of the worked bone from Emborio and Ayio Gala prior to publication. The worked bones have not been identified as to species but several, including the scoops made on pig fibulae were clearly recognisable from illustrations.

27 The epiphyses have been removed and incisions occur on the shafts. They have been identified by Banks as 'divider beads' although she recognises this cannot be verified: Banks, _op. cit._ (note 11), p. 463-4. Two other fox metapodials have been identified by Banks as 'Bone pendants'. See pl. 100, fig. 111.

28 In common with other items such as shells and teeth which may or may not have been used as ornaments, fish spines are not catalogued. See also Type 52. See pl. 100.

29 H. Hodges, _Artifacts: an Introduction to Early Materials and Technology_ (London, 1964), p. 153 ff.

30 Cornwall, _op. cit._ (note 1), p. 67 ff. There appears to be no single good work on antler as a material, but see also short sections in Chaplin, _op. cit._ (note 1), p. 89 and Hodges, _op. cit._ (note 29), p. 153 ff. On the shedding of antler see: 'Deer' in _Encyclopaedia Britannica_ (1970) vol. 7, p. 165 and G. Kenneth Whitehead, _Deer of Great Britain and Ireland_ (London, 1964), pp. 450-52.

31 Hodges, _op. cit._ (note 29), p. 155.

32 Andrzej Kempisty, 'Methods of Bone and Horn Working in the Funnel Beaker Culture', _Wiadomości Archeologiczne_ 27 (1961), pp. 133-43. (In Polish with English summary).

33 For comparative material see references on introductory pages to Types 22 and 23 in the Catalogue.

34 For Thermi, see Dorothea M.A. Bate's report on the faunal remains in Lamb, p. 216; Troy: Blegen III p. 123 and _passim_. Thera: Sp. Marinatos, _Excavations at Thera VI_ (Athens, 1974), p. 42, colour plate 9.

35 Gamble, _op. cit._ (note 6), p. 752 quoting pers. comm. M. Jarman.

36 _ibid._, pp. 747, 752.

37 Hodges, _op. cit._ (note 29), p. 155.

38 Extensive inquiries during the summer of 1980 did not produce any samples of red deer antler, either fresh or shed, for experiment and study. Few red deer herds remain in south-eastern England; for the most part, park deer are of the fallow variety. The Royal Agricultural Society in Warwickshire retains only one stag from the herd which they recently purchased from Whipsnade Zoo. At the time of writing I hope to be able to obtain some shed antler from Woburn Park after the 1981 rutting season.

39 Whether tusks other than the lower canines (i.e. incisors or upper canines) were ever used for helmet plaques is not documented.

40 Brea I, p. 670, pl. CLXXVIII, 5. (With large central hole). Worked boar's tusk is not given full catalogue treatment but see under Types 53 (Helmet plaques) and Types 69, 73 and 75.

41 CMS I, no. 227 (ANM 1772)

42 PM I, p. 718, fig. 541a.

43 Eutresis I, p. 220 fig. 290 nos. 4-16 helmet plaques, nos. 17-19 unworked tusks.

44 I am grateful for permission from Mr. I, Tzedhakis to study material at Khania.

45 For example, A.C. Renfrew, The Emergence of Civilisation (London, 1972), p. 446.

46 T.K. Penniman, Pictures of Ivory and other Animal Teeth, Bone and Antler (Pitt Rivers Papers no. 5) (Oxford, 1952), p. 30.

47 Ī. Sakellarakis, To elephantódonto kai i katergasía tou sta mykinaïka khronia (Athens, 1979), p. 1 gives a good list of the words for ivory in other languages including the large number of Greek variants. 'Phildisi' or 'philndisi' is a word of Turkish origin and may also be applied to mother of pearl as in AD 30 (1978) A, p. 82 regarding a find in this material from Thebes.

48 Sylvia, A.K. Sikes, Natural History of the African Elephant (London, 1971), pp. 81-82.

49 N.S. Baer, N. Indictor, 'Chemical Investigations of Ancient Near Eastern Archaeological Artifacts', in Archaeological Chemistry (Advances in Chemistry no. 138), ed. Curt W. Beck (Washington, D.C. 1975), pp. 236-245.

50 Sikes, op. cit. (note 48), p. 81.

51 ibid., pp. 81-82.

52 ibid., pp. 81-82.

53 I am indebted to Lord William Taylour and the publication committee of the Citadel House excavations for permission to study and publish the bone and ivory objects. The site and contexts of the objects are more fully discussed in Chapter VIII. The head and lion have already appeared in preliminary reports (see Catalogue) and are now stored in the main part of the Nauplion Museum, although are not yet on display. I was unable to examine these either in 1978 or 1979. All the remaining objects are in the Mycenae apotheke in the Leonardon, Nauplion.

54 Sikes, op. cit. (note 48), pp. 81-82 and Penniman, op. cit. (note 46), p. 13, pls. I and II.

55 'The Care of Ivory', Technical Notes on the Care of Art Objects no. 6 (Conservation Department of the Victoria and Albert Museum: London, 1971). Packing ivory in cotton wool will only add to post-excavation deterioration from moisture. Plastic bags are equally inadvisable as they allow condensation to collect. If ivories must be cushioned from shocks, small boxes lined with hard tissue paper are least likely to cause harm. (personal experience and 'The Care of Ivory').

56 Carson I.A. Ritchie, Ivory Carving (London, 1969), p. 29.

57 ibid., p. 42 and personal observation.

58 ibid., p. 41. Ritchie does not, however, feel that the Mohs scale is a very reliable guide to the hardness of ivory (p. 126) and offers alternative descriptions based on a scale of 'soft' to 'very hard' for different types of ivory (p. 127).

59 I am most grateful to M.S.F. Hood for his permission to study the large collection of ivory objects and debris as well as bone implements from the excavations on the Royal Road. The material is housed in the Stratigraphical Museum, Knossos. My thanks to Dr. Hector Catling, Director of the British School at Athens and Dr. Jill Carrington Smith, formerly Knossos Fellow for arranging access to the material in 1978 and 1979.

60 One curious piece has been discovered at Troy II. See Blegen I, p. 316 cat. no. 37-568. It is a rare double-ended implement described as either ivory or unidentified leg bone in the catalogue, although in the tabulations for Troy II it is listed under ivory. I am inclined to doubt this.

61 It is impossible to produce accurate statistics for the ratios of bone to ivory pins in the LBA owing to possible inaccuracies in the identification of material in published sources. I strongly suspect that ivory was too easily fractured to permit widespread adoption of that material for pins. See also below p. 78 and 221.

62 A recent report places the price of solid tusk at about £50 per pound. When I purchased some samples in late 1976 the price was about £10 for solid tusk and £5 for waste (off-cuts from other processes). I cannot say where in England one may now purchase the material: Messrs Freidlien and Sons 'Natural Products Ltd.' appear to have gone out of business as has another supposed ivory warehouse in London. I suspect that they have simply gone 'underground'. Protestations by Freidlien's in 1976 that they never dealt in contraband or illegal ivory did not ring true and I was carefully guided away from certain sections of their warehouse in the East End of London.

63 Dr. C. Zerner, pers. comm. at Argos Museum, May 1979 and also see Banks, op. cit. (note 11), pp. 480-82.

64 Brea II, pp. 298-302, pl. CCLIV.

65 See P.M. Warren, 'The Primary Dating Evidence for Early Minoan Seals', Kadmos 9 (1970), pp. 29-37. Warren identifies three of the six seals from this level as ivory (HM 2005, 2008, 2011). HM 2005 is bone (chapter III, p. 82); 2008 and 2011 might be ivory, although identification is not positive (see Appendix III). Warren identified HM 2006 also from this stratum as 'brown serpentine'. It is in fact one of the small ring-shaped seals of bone (Appendix III).

66 K. Branigan, Foundations of Palatial Crete (London, 1969), p. 142 suggests that approximately 70% of the seals in MMIa were made of ivory compared to about 30% of the seals in EMII. If anything, in view of the use of local materials for some of the 'ivory' seals, his figure for the EMII period may be a little high. See also chapter IV, p. 151 n. 24.

67 Paul Yule, pers. comm., July 1979.

68 I am grateful to Professor St. Alexiou and Professor P.M. Warren as well as the Ministry of Culture for permission to study the Lebena collection in the Iraklion Museum. My thanks also to Mr. I. Tzedhakis, Acting Director in June 1979. The descriptions of the seals in the Iraklion Inventory were obtained for me by Miss Nota Demopoulou in October 1979 (pers. comm.).

69 My particular thanks to Professor N. Platon for permission to study and photograph the Zakro tusks as well as the staff of the Iraklion Museum who facilitated this by locating the two badly damaged tusks housed in the Zakro storerooms of the museum. The numbering of the tusks is my own, see pls. 23 and 24. Numbers 3 and 4 have deteriorated badly (see pl. 24b for close-up). Measuring and even photographing the tusks was exceedingly difficult as pieces of ivory fell off with the slightest movement of their wooden box. Although they have been partially conserved and one made up on a plaster of Paris mould, their state is precarious.

70 I owe the method illustrated on Figure 12b to Dr. Stephen Ginn, Lecturer in Mathematics, Birkbeck College, University of London. Confronted with the problem, he decided that conventional methods for calculating the volume of an object would be of little use, neither would a computer be of great assistance. pers. comm., August 1980.

71 Of course we are dealing only with extant items and it would be most difficult, if not impossible, to estimate the actual number of tusks imported during the pre-palatial period.

72 S. Xanthoudides, The Vaulted Tombs of the Mesara (London, 1971 reprint), p. 123, nos. 1031, 1032, 1142. I understand that there are also a number of unpublished blanks from Ayia Triada: Paul Yule, pers. comm., 1979.

73 CMS IV, passim (see also Type 55 in the Catalogue).

74 See also O.T.P.K. Dickinson, Origins of Mycenaean Civilisation (SIMA XLIX) (Göteborg, 1977), p. 35 n. 39. Dr. Dickinson, who has seen the piece, says it is indeed ivory and the decoration suggests mainland workmanship (pers. comm.).

75 I am grateful to Professor A.C. Renfrew for permission to mention this unpublished material. The Middle Cycladic date must, of course, remain provisional until the final publication appears.

76 V.E.G. Kenna, Cretan Seals (Oxford, 1960), p. 32 n. 8 and comment by Branigan, op. cit. (note 66), p. 142 n. 1

77 Paul Yule, pers. comm., March 1978.

78 See 56b: 19, 56c: 13, and 59: 14 all from Chrysolakkos. Other small inlays said to be bone have been recovered elsewhere in the Mallia area (see under Types 56 and 59). The manufacture of bone plaques at Mallia has been discussed in a brief conference paper: R. Jullien, 'L'industrie de l'os chez les minoens de Malia (1800 B.C.) Crète', in Colloque I, p. 105.

79 see 74: 38 and Sinclair Hood, The Arts in Prehistoric Greece (Harmondsworth, 1978), pp. 120-21.

80 In conversation, April 1979.

81 Dr. E.V. Schofield, pers. comm., December 1978.

82 See H.-G. Buchholz, 'Some Observations Concerning Thera's Contacts Overseas during the Bronze Age', in Thera and the Aegean World (London, 1980), Vol. II, p. 229. 'Sp. Marinatos believed that the population of the Bronze Age settlement managed to escape and evacuate all their treasures.'

83 Sakellarakis, op. cit. (note 47), p. 17 ff. and S. Symeonoglou, Kadmeia I (SIMA XXV) (Göteborg, 1973), p. 44 ff.

84 In conversation with Lord William Taylour, March 1980 and Sakellarakis, op. cit. (note 47), p. 19.

85 Taylour in AR (1962-63), p. 15: 'Of particular interest was the discovery in the basement room of a complete section of an elephant's tusk'. Similarly in AD 18 (1963) B., pp. 82-84 with the further comment: 'This taken together with the many fragments of ivory found suggests that the room was used as a workshop'.

86 P.E.P. Deraniyagala, Some Extinct Elephants, their Relations and the Two Living Species (Colombo, 1955), p. 28.

87 H.H. Scullard, The Elephant in the Greek and Roman World (London, 1974), p. 26.

88 CAH II.1, pp. 329-30.

89 ibid., p. 337.

90 I am most grateful to Professor J.D. Evans for permission to study his remains in worked bone from the investigations into the Knossos neolithic and to discuss the unpublished piece of hippopotamus tusk which is presented below p. 70 .

91 William A. Ward, Egypt and the East Mediterranean World 2200-1900 B.C. (Studies in Egyptian Foreign Relations during the First Intermediate Period) (Beirut, 1971), p. 97 ff.

92 ibid., p. 120 ff. An MMIa bridge-spouted jar is attested in an Early Cypriote III tomb: H. Kantor, The Aegean and Orient in the Second Millenium B.C. (Bloomington, Indiana, 1947), p. 18. It is quite possible that at this and later stages Cyprus played a part in the dispersal of ivory from the near east, whether Syria or Egypt.

93 For example: E. Vermeule, Greece in the Bronze Age (Chicago, 1972), p. 219 who regards it as a 'finished import which helped to disseminate Levantine techniques and motifs.' Poursat lists it among his imports (Iv. Myc. p. 231), a view upheld by Barnett, rev. Poursat in JHS 100 (1980), p.286 (wrong ANM number cited).

94 Hood, op. cit. (note 79), p. 127. G. Mylonas, Mycenae and the Mycenaean Age (Princeton University Press, 1968), p. 196 view it as the 'work of a gifted Mycenaean artist at the end of the fourteenth century.' See also Poursat cat.no. 301 for full references.

95 N. Platon, Zakros: The discovery of a lost palace of ancient Crete (New York, 1971), p. 245. According to Professor Platon, photographs of the tusks were taken to New York by Mr. Pomerance where he showed them to an 'expert' who apparently said they were Syrian. (Conversation with Prof. Platon, April 1979).

96 Deraniyagala, op. cit. (note 86), p. 116.

97 ibid., p. 117.

98 ibid., p. 117. On overkill, see Hood, op. cit. (note 79), p. 117 and note 27.

99 Deraniyagala, op. cit. (note 86), p. 116. The monuments are the obelisk of Shalamanassar III (ca. 1100 B.C.) in the British Museum and the Tomb of Rekhmire paingings. See N. de G. Davies, The Tomb of Rekh-me-re at Thebes (London, 1943).

100 Deraniyagala, op. cit. (note 86), p. 116 and pl. 45, 1.

101 ibid., p. 116.

102 ibid., p. 116 and idem, 'The Elephant of Asia', (Presidential Address to the Ceylon Association of Science, Colombo, 1949), p.11.

103 Deraniyagala (1955), op. cit. (note 86), p. 116.

104 There is, in fact, some disagreement about the value of tusks for differentiating between species. Hooijer (see below p. 58 n. 107) apparently does not believe that they can be used for this purpose.

105 I have not made an intensive study of representations of elephants but have occasionally seen the hoofed depictions on corbels in English parish churches. The guide to St. Mary's Beverley (E. Yorks.) states that the elephant depicted on one of the misericords, work of the Ripon Carvers ca. 1445, is one of the earliest accurate representations in England. W.C.B. Smith, 'St. Mary's Church, Beverley' (Jarrold and Sons, 1979), inside back cover.

106 Sebastian Payne, pers. comm.

107 D.A. Hooijer, 'The Indian Elephant at Bronze Age Ras Shamra, Ugarit' and 'Report on an Elephant Molar from Ras Shamra, Ugarit 31-10-1060 (125 W, Point 2971)', in Ugaritica VII. I am most grateful to Miss Jenny Webb of the British School at Athens who spotted this reference for me.

108 ibid., p. 188-89.

109 Penniman, op. cit. (note 46), p. 18. The ivory in my collection is supposedly from the African elephant and I have not knowingly handled any Asian ivory. On my trip to Freidlien's (n. 62) they impressed upon me that no Asian ivory ever came into their hands as it was illegal. See also my comments Chapter III n. 28.

110 To my knowledge there is but a single reference to the possible use of hippopotamus tusk as ivory in the Aegean. A.W. Persson (NTD, pp. 145-46) comments: 'A closer examination is required of the ivory objects found in the Aegean, it would probably show that many of the so-called ivory objects . . . are not made of elephant tusk but of hippopotamus teeth as in Egypt.' The date of publication (1942) is worth noting.

111 Penniman, op. cit. (note 46), pp. 23-24; pls. VI and XX.

112 Dr. R.M. Laws, now Director, the British Antarctic Survey, Cambridge, pers. comm. His article on 'The Dentition and Ageing of the Hippopotamus', East African Wildlife Journal 6 (1968), p. 19 ff. was also of assistance in making the initial identification. I am grateful to Major A.B. Vickery who discovered this article for me while I was working with the tusk in Greece.

113 I am very pleased that Mr. Payne was able to examine the tusk and offer his opinions about its conditions.

114 This suggestion was also offered to me by Dr. E.B. French, a senior member of the Citadel House team in April 1980. The scientific and archaeological basis for this will require further exploration.

115 Conversation with Dr. I. Maniatis of the Demokritos Laboratory, Athens, July 1979. His views were, it must be stressed unofficial and formed without handling the object.

116 Suggestion made by Dr. Forbes in July 1980.

117 I am preparing the fascicle on 'Ivories and Bone Tools' as part of the series Well Built Mycenae: The Helleno-British Excavations within the Citadel at Mycenae, 1959-69, eds. Lord William Taylour, E.B. French, K. Wardle.

118 Verified by both Sebastian Payne and Dr. C. Forbes.

119 G.J. Boekschoten and P.Y. Sondaar, 'The Pleistocene of the Katharo Basin (Crete) and its Hippopotamus,' Bijdragen Tot Dierkunde 36 (Amsterdam, 1966), p. 37.

120 On the Megalopolis Fossils see: J.K. Melentis, 'The Natural Setting', in History of the Hellenic World: Prehistory and Protohistory, ed. George Phylactopoulos (Athens, 1974), pp. 18-25; and idem, 'Studien uber fossile Vertebraten Griechenlands', Annales Géologiques des Pays Helleniques, 16 (1965). Also Th. Skouphos in 'Beziehung auf das Vorhandensein des Menschen', Comptes Rendus I Internationale Congres d'Archeologie (Athens, 1905), pp. 231-36.

121 D.S. Reese, 'Dwarfed Hippos: Past and Present', Earth Science 28 no. 2 (1975), p. 66. G.J. Boekschoten and P.Y. Sondaar 'On the Fossil Mammalia of Cyprus I and II.', Proc. Koninkl. Akademie van Wetenschappen series B, 75 no. 4 (Amsterdam, 1972) pp. 306-338.

122 The tusks which I examined are in the possession of D.S. Reese, St. John's College, Cambridge, who has studied the question of dwarf hippopotamus for some time. I would like to acknowledge his assistance in this matter and for suggesting various references.

123 Mentioned by D.S. Reese in 'Men, Saints, or Dragons?', Expedition 17 no. 4 (summer 1975), p. 27. The original reference may be found in D.M.A. Bate, 'On a New Genus of Extinct Muscardine Rodent from the Balearic Islands', Proc. Zoo. Soc. London (1918), p. 221.

124 Pausanias VIII.32.5.

125 Reese, op. cit. (note 123), pp. 27, 29.

126 The opinions on the Citadel House ivories presented here and elsewhere in this study are my own, based on several months work with the objects themselves and some reference to excavation notebooks. The introduction to the series Well Built Mycenae prepared by Lord William Taylour should appear shortly. I have been able to read it in MSS version. The dates for the objects were established for me by Dr. E.B. French in 1978, for which I am most grateful.

127 In fact in preliminary reports, see note 85 above, the excavator reported there were no traces of burning in Room II.

Page
missing

139 There is one more specimen of hippopotamus lower canine worth mentioning here. It was discovered by D.S. Reese while examining faunal remains from Hala Sulta Tekke in 1980. The piece presented both Reese and myself certain problems of identification because it is about one-half of a very small tusk roughly the size of a large boar's tusk. Reesewho is experienced in pleistocene hippopotamus remains (above n. 121) felt certain that it could not be from the extinct dwarf Phanourios minor (p. 64). Eventually we concluded that the specimen was from a juvenile which has recently been confirmed by Dr. R.M. Laws. Nonetheless the presence of a juvenile tusk, which would yield a very small amount of solid ivory, on Cyprus presents enormous problems of interpretation which cannot be tackled here. The context has been provisionally dated by the excavator, Dr. Paul Astrom, to Late Cypriote II.

140 Penniman, op. cit. (note 46), p. 23. My own tusk measures 15 inches from end to tip and weighs 3 lb. 15 oz. (1.5 kilograms).

141 Ritchie, op. cit. (note 56), p. 49.

142 ibid., p. 35

143 ibid., p. 42. The analogy to a sandbank, very apt, is Ritchie's.

144 Sir Richard Owen, Odontography: or a Treatise on the Comparative Anatomy of the Teeth etc. (London, 1840). The following sections are relevant: 'Microscopic Structure of Elephant Ivory' vol. I p. 640; 'Hippopotamus Teeth' vol. I. p. 563 and 'Microscopic Structure of Hippopotamus Teeth' vol I p. 567 where the figure 1/14,000th inch is cited. See also Sir Charles Tomes, 'Hippopotamus Teeth', in Tomes' Dental Anatomy, ed. H.W.M. Tims and C.B. Henry (London, 1923).

145 See both Ritchie, op. cit. (note 56), p. 49 and Penniman op. cit. (note 46), p. 23 for the whiter appearance of hippopotamus teeth.

146 Penniman, op. cit. (note 46), p. 23 referring to worked hippopotamus tusk in the Ashmolean Museum.

147 Until offered a tusk by Dr. Laws in spring 1981 I had been unable to obtain any hippopotamus ivory. Until I have gained more expertise in carving elephant ivory and perhaps located a supplier of hippopotamus tusk, I am reluctant to sacrifice the lower canine which I possess for experimental purposes.

148 Sebastian Payne, pers. comm., May 1979.

149 The difficulties presented by differences in present appearance of ivory objects and the effect of high temperatures which may distort the physical state and colour will be discussed in the following Chapter (III) on identification of materials.

150 I am convinced that careful examination of faunal remains from sites in the Aegean, not merely of bronze age date, will yield further evidence for hippopotamus tusk. For example from Samos there are reports of 'walrus tusk' ('Walrosszähne') so identified because the 'curve is too small to be from an elephant' (pers. comm. from Elisabeth Unterkircher of the German Archaeological Institute to D.S. Reese). See also Ath. Mitt. 83 (1968), p. 303 no. 170, pl. 138, 3,4. The tusk is certainly a hippopotamus lower canine. I have also discussed the matter with Professor Homann-Wedeking who immediately recognised my photographs of the Mycenae tusks as similar to ones he had seen on Samos.

NOTES TO CHAPTER III

1 V.E.G. Kenna, Cretan Seals (Oxford, 1960), appendix I, p. 28 ff. 'The earliest Cretan seals which are extant have been made from sections of an ivory tusk. The natural form of the tusk was retained as far as possible, especially when a recognisable part of a tusk was used . . .'. Few of the assertions regarding ivory made by Kenna in this section can be substantiated from a careful study of the seals.

2 But see Chapter II note 45.

3 Miss K.J. Scott, pers. comm.

4 N. Platon, 'Mia sphragistiki idiorrythmia tis proanaktorikis minoikis periodou', Festschrift für Friedrich Matz (Mainz, 1962), pp. 14-18.

5 See 'Shoulder-shaped seals' under Type 55 in the Catalogue (Vol. II, p.260) for relevant numbers. Three more in 'ivory' also exist in the Metaxas Collection from Lebena.

6 I am grateful to Helen Hughes-Brock for inviting me to examine the bone and ivory seals in the Ashmolean Museum and to Michael Vickers for permission to study them.

7 The shoulder seals HM 1109-1112 and 1211-1213 are housed in case number 32 of the Scientific Collection in the Iraklion Museum. I am indebted to Mr. I. Tzedhakis, Acting Director in 1979, for permission to view certain objects in the cases of this collection. Unfortunately, Ministry of Culture permission was not granted to study a selected number of seals from Ayia Triada, Platanos and Marathokephalo, although they have long been published and most were in the Scientific Collection not in the public galleries. Although no reasons were given, it must be surmised that staffing problems at the museum during 1978 and 1979 necessitated restrictions on access.

8 HM 434, 435, 495 and 507 all in case number 32 of the Scientific Collection, Iraklion Museum.

9 Since many of these morphological features can be isolated in the excellent photographs in CMS, this approach might well be adopted where access to museum collections is restricted and only small numbers of seals can be examined.

10 So deceptive are certain aspects of this piece that preliminary sorting placed it in the 'ivory small finds' boxes of the Royal Road (1957-61) excavations where it remains today.

11 Although as indicated in Chapter II, p. 29 to a non-specialist, a heavily worked piece of antler might resemble bone. Similar difficulties may be caused by working from photographs alone.

12 The material of these pieces was likewise identified by J.P. Coy the faunal expert who examined the Kea collection.

13 _BSA_ 36 (1935-36), pp. 98, 101, no. 10a and fig. 21; _CMS_ II.1 no. 440.

14 Most of the ivory objects from the Citadel House, Mycenae have been conserved with PVA. In at least one case the brush strokes from applying that substance were so thick that the PVA had to be removed before proceeding with the identification of the material.

15 Penniman, _op. cit._ (Chapter II, note 46), p. 31

16 Banks, _op. cit._ (Chapter II, note 11), p. 289.

17 H.J. Plenderleith, _The Conservation of Antiquities and Works of Art_ (Oxford, 1956), p. 150. For the Munsell numbers see: _The Munsell Book of Color_, Munsell Color Company, Baltimore, Maryland, USA.

18 N.S. Baer, N. Indictor, J.H. Frantz and B. Appelbaum, 'The Effect of High Temperature on Ivory', _Studies in Conservation_ 16 (1971), pp. 1-8.

19 _ibid._, p. 2.

20 The tables are reproduced by the kind permission of Professor N.S. Baer and the London office of the International Institute of Conservation (IIC). Tables 4 and 5 are taken from Baer, _et al._, _op. cit._ (note 18) while Table 6 and 7 are from the work cited note 21 below.

21 N.S. Baer, B. Appelbaum, N. Indictor, 'The Effect of Long-Term Heating on Ivory', _Bulletin of the American Group - IIC_ 12 no. 1 (October, 1971), pp. 55-59.

22 _ibid._, p. 55.

23 Plenderleith, _op. cit._ (note 17), p. 150 quoted by Baer, _et al._, _op. cit._ (note 18), p. 4.

24 As colour plate VIb shows, there are some pieces dark grey-blue which belong to the category of waste or scrap ivory discussed in Chapter IV. On the whole these show greater deterioration of physical structure than do the square inlays. Whether heavily worked ivory is less susceptible to affects of burning than partially worked pieces is not known.

25 No Munsell charts were available during the study of this material and consequently colour designations are approximate.

26 Penniman, op. cit. (Chapter II, note 46), p. 9. Note that these are taken of sections of the raw materials.

27 For my own studies I used only an Opax stereo microscope with x 15, x 30 and x 45 45 magnifications. It is small and easily portable but cannot be used in conjunction with a camera. On the whole it served quite well and its portable nature and initial cost must be weighed against those benefits which a large piece of equipment might yield. With hindsight it is easy to see that the facility for taking microphotographs would have been beneficial.

28 N. Beccari, 'Caratteri struturali dei manufatti etruschi di osso e di avorio', Studi Etruschi 3 (1929), pp. 387-96. I am most grateful to Helen Hughes-Brock for drawing this article to my attention. Beccari's photographs are most instructive but extreme caution must be exercised in reading his conclusions on types and qualities of ivory (pp. 393-94). There is little evidence to support his view that the classes of ivory can be related to elephant tusks of different geographical origins.

29 The piece broke along this line during handling and needed further repair.

30 Penniman, op. cit. (Chapter II, note 46), pl. XIV.

31 N.S. Baer, N. Indictor, 'Chemical Investigations . . .' op. cit. (Chapter II, note 49), pp. 236-45.

32 Dr. R.M. Laws, pers. comm., March 1981.

NOTES TO CHAPTER IV

1 Noted by Major A.B. Vickery who undertook the preparation of a study collection on my behalf during the spring of 1981. Steel scalpels were used to remove the ligaments. I am also grateful to John O'Toole, Master Butcher, who supplied the bone.

2 Hodges, op. cit. (Chapter II, note 29), p. 155.

3 For the use of oxalic acid derived from sorrel leaves, see Chapter II note 32. Kempisty summarises the work of K. Żurowski who experimented in softening antler (horn) by means of soaking in the acid solution. The range of softening could be regulated by length of time devoted to soaking. The value of the experiments is reinforced by the discovery of sorrel seeds on a number of mediaeval sites in Poland. Moreover, according to Kempisty the antler working techniques of the Funnel Beaker culture in Poland indicate that some form of softening must have taken place, although no sorrel seeds have, as yet been discovered in such contexts. Other experiments have involved soaking antler in urine: reported by Mark Newcomer in a lecture on experimental bone working to the Prehistoric Society, 12 March 1977.

4 Newcomer in lecture cited above note 3.

5 For reference see Catalogue: 74: 1, 37, 38, 39 and Chapter II note 75 for Phylakopi.

6 For illustrations of this method see: F. Poplin, 'Deux cas particulier de débitage par usure'. In Colloque I, pp. 85-92, figs. 7-11. Also M. Newcomer op. cit. (Chapter II note 13), p. 293-301, especially fig. 2. Newcomer points out that brute force alone will not extract the splinter of bone which is one reason for the horizontal grooves to be cut near the epiphyses. Antler, especially when soaked, with its greater flexibility does not require this additional working. Once the grooves have reached the cancellous material within the splinters may be levered up (pp. 294-295).

7 Banks, op. cit. (Chapter II, note 11), p. 466. Banks says that both ends are cut off straight; perhaps the piece has been broken since she examined it.

8 Compare with the splinter illustrated by Newcomer, op. cit. (Chapter II, note 13), p. 295, fig. 2.

9 For the shape see comment on Type 11, Chapter VII, p. 220. This piece comes from the destruction debris in Room xxi but the other Citadel House examples cannot be dated more nearly than 'LHIIIc and earlier' (See p. 285). Regarding this particular piece Lord William Taylour has written that 'it appears to be a stylus that could have been used on papyrus but would have been ill-adapted for writing on clay tablets (according to information given by John Chadwick)': from introductory fascicle, Well Built Mycenae (forthcoming, 1981). This interpretation is clearly incorrect and the piece must be regarded simply as an unfinished pin of bulbous headed variety.

10 Information from site records. The contexts of the pieces are discussed in more detail p. 284 below.

11 See also Sakallarakis, op. cit. (Chapter II, note 47), p. 53.

12 Lord William Taylour, Antiquity 43 (1969), p. 94 quoted by Sakellarakis, op. cit. (Chapter II, note 47), footnote 72.

13 The uneven lower edge would of course be removed during the cutting of the teeth and the shape would become rectangular rather than square as is more common for combs. The suggestion that this piece may have been a blank for comb manufacture is of course only tentative; however other end products are even less easy to relate to its present appearance. Apart from the slightly tapering section, the present thickness of the piece makes a relief plaque rather unlikely.

14 Sakellarakis, op. cit. (Chapter II, note 47), pp. 40, 55-56 and figs. 44-47, 50.

15 Possibly confirmed by the find of partially worked ivory in Grave Circle A (V), 74: 36.

16 Sakellarakis, op. cit. pp. 20-39 and A.J.B. Wace, 'Preliminary Reports on Excavations of 1953', BSA 49 (1954), p. 233 ff.; and idem., 'Preliminary Reports of 1954', BSA 50 (1955), p. 180 ff.

17 Sakellarakis, op. cit. (Chapter II, note 47), p. 38 and figs. 42, 43.

18 ibid., fig. 29 from the House of the Shields and fig. 13 for fragments from the 'artisans' workshop' on the acropolis.

19 Peg wedges or 'wasters' have also been found at Kouklia on Cyprus but so far only one peg has been recovered. Dr. F.-G. Maier, pers. comm., March 1979.

20 There is one piece, an ivory column (74: 10) which might still require final polishing to give it a more rounded section. It is the only example of this type (Type 61: Columns) in the Royal Road material housed in the Stratigraphical Museum, Knossos.

21 DS, p. 358, pl. 47 nos. 1,2,5,12. See also introductory page to Type 36 in the Catalogue.

22 For micro-wear patterns see further below p. 174. Sometimes even low magnifications can give indications of whether the working end was used. Time and quantity of objects to be examined did not permit a detailed examination of all working ends under the microscope.

23 The type of drill used to make string-holes in bone or ivory seals in the pre-palatial period has not been established. The preservation of abrasion marks from the drill is said to be extremely rare, unlike those on stone (confirmed by own observations). See R.G.D. Evely, 'Minoan Crafts: Tools and Techniques', (D. Phil. thesis, Oxford, 1979), p. 350.

24 in 'Wealth and Prosperity in Pre-Palatial Crete: the Evidence of Ivory', paper presented to the Cambridge Colloquium on Minoan Society, 30 March - 2 April 1981 and to be published in Minoan Society, ed. L.F. Nixon and O.H. Krzyszkowska (Bristol Classical Press, 1982). See also Chapter II (note 65) regarding the materials of seals in Lebena Tomb IIa and Appendix III for catalogue of the seals.

25 Sakellarakis, op. cit. (Chapter II, note 47), p. 34, fig. 36.

26 Evely, op. cit. (note 23), p. 341.

27 Hood, op. cit. (Chapter II, note 79), pp. 119-120 and note 38; idem, in AR (for 1957), p. 22, pl. 2a.

28 Hood, op. cit., (Chapter II, note 79), p. 122; fig. 122. Katsambas, pp. 55-56 no. 9 (HM 345), pls. 30-33; and Evely, op. cit. (note 23), p. 332.

29 Here it is worth mentioning an observation made in connection with the term inlay as applied to strips, squares etc. Referring to bone and ivory inlay strip from MBA Palestine, H. Liebowitz points out that 'inlay' is misleading since most strips were pegged to boxes. The same might be said of the Aegean strips, although for conveniĕnce the term inlay will be retained. Items such as rosettes and lilies may have been true inlays. See H.A. Liebowitz, 'Bone and Ivory Inlay from Syria and Palestine', Israel Exploration Journal 27 no. 203 (Jerusalem, 1977), p. 81 ff.

30 Evely, op. cit. (note 23), p. 343 and appendix 4 also believes that the marks were a kind of code to ensure correct positioning.

31 Sakellarakis, op. cit. (Chapter II, note 47), p. 58 ff and p. 66.

32 Since Evely and I were working on the same group of material from the Royal Road, I did not consult his study of Minoan Crafts (op. cit. note 23) until after my own fieldwork and observations were completed. We did however have several profitable discussions on the material in 1978-79.

33 Sakellarakis, op. cit. (Chapter II, note 47), p. 46 ff.

34 Ritchie, op. cit. (Chapter II, note 56), p. 18 and Evely, op. cit. (note 23), p. 320. Ritchie's remarks in his appendix II ('Marks left by the Tools of the Ivory Carver'), pp. 123-25 are most useful since Ritchie himself is an experienced ivory carver. His remarks regarding the reconstruction of stages in ivory carving are particularly apposite. 'First of all determine what tools were available to the person who carved it. This is usually the point on which it is most difficult toget any information at all. I have never seen an illustration of the complete tool kit of any ivory carver of any period or country.' He goes on to say: 'Do not assume that because a particular country or period possessed a tool that is was used on ivory.'

35 Banks, op. cit. (Chapter II, note 11), pp. 177-188, especially pp. 185-86 and pl. 6.

36 See R. Jullien, op. cit. (Chapter II, note 78), pp. 105-06.

37 Evely, op. cit. (note 23), p. 331.

38 Sakellarakis, op. cit. (Chapter II, note 47), p. 46, figs. 51, 52.

39 Evely, op. cit. (note 23), p. 349, although apparently they are not well represented in the repertoire (p. 73).

40 ibid., p. 338.

41 ibid., p. 340.

42 ibid., p. 351 and p. 343.

43 Iv. Myc., p. 43 ff.

44 Sakellarakis, op.cit. (Chapter II, note 47), p. 56. Major Vickery informs me that in South-east Asia, Chinese craftsmen sometimes use shark's skin as a polishing agent.

45 Banks, op.cit. (Chapter II, note 11), p. 333. Dr. C. Zerner, who is publishing the Lerna V material, has kindly informed me of the floor levels to which the eight objects belong. Floor 1: 2 pins (11c: 31, 32) and a pointed implement (8b: 18). Floor 2: 3 undiagnostic pin fragments (11e: nos. L4 232, L4 239, L4 256), and a pointed implement, unclassified (Type 14: L4 257). Floor 3: one pointed implement only (8b: 19). All floors dated to Lerna V a.

46 For example the 'Atelier des Sceaux' at Mallia, see BCH 81 (1957), p. 693 ff. and BCH 102 (1978), pp. 831-34 dated to MMII. Also the new 'Atelier de potier' manufacturing items of a religious nature in the vicinity of the Quartier Mu during the first palace period. (Reported by J.-C. Poursat in 'Ateliers et sanctuaires' paper presented to the Cambridge Colloquium on Minoan Society, 30 March - 2 April, 1981.)

47 Iv. Myc., p. 179.

48 'Workshops' in the stylistic sense are not considered here. See Iv. Myc., section II 'Diversites Geographiques' (pp. 141-176). The mainland 'workshops' are considered on pp. 170-76.

49 Sakellarakis, op.cit. (Chapter II, note 47), pp. 45-46. See also below Chapter VII (Type 13) and Chapter VIII, p. 287.

50 I have not examined the bronze objects from the Royal Road therefore my knowledge of them is rather limited.

51 There may have been other ivory workshops at Knossos. Evely reports possible 'wasters' from the Unexplored Mansion, op.cit. p. 348. I have examined some of the MUM material myself in order to assist Evely with identification of materials. There are several examples of partially worked bone but whether these were connected with bone and ivory working on the site or are merely stray pieces is not yet known. I mention the MUM material with kind permission from Mr. Mervyn Popham and Mr. Hugh Sackett although it should be noted that the views are unofficial pending the full publication of the site.

52 Preliminary reports by G.E. Mylonas, 'Anaskaphi Mykenon', Praktika (1965), pp. 85-96; idem, 'The East Wing of the Palace of Mycenae', Hesperia 35 (1966), pp. 419-426, pl.96; and summary by Sakellarakis, op.cit. (Chapter II, note 47), pp. 17-18, fig. 13.

53 Sakellarakis, op.cit. (Chapter II, note 47), pp. 20-39 and passim.

54 Poursat has also remarked on the difficulties of accepting Wace's interpretation for these houses, benefitting from an examination of the wastes or roughouts during his study of the material in the ANM. He sees the houses as possibly linked to some kind of commercial activity, not necessarily a workshop per se, but a kind of entrepot. He also suggests that the houses could have served as workshops for the assembly of furniture decorated with ivories. ('un atelier où l'on adaptait les ivoires aux meubles qu'ils devaient décorer').

55 Symeonoglou, op. cit. (Chapter II, note 83) and Iv. Myc. p. 136.

56 See PN I, pp. 323-35 for the identification of a 'Palace Workshop' which was devoted 'to the making of delicate objects in bronze and ivory'. Poursat's arguments against this interpretation (Iv. Myc. p. 137) are certainly correct. He rightly notes that no one can doubt the existence of a workshop in the Pylos palace complex which produced the finished pieces found in the palace but that the actual working area has not been located. For references to ivory on the Pylos tablets see Iv. Myc. p. 257 ff.

57 The Nichoria find of partially worked ivory (74: 37) has been dated to LHII-IIIa. It is impossible to say whether by the LHIIIb period all ivory working in Messenia was centred on Pylos.

58 Sakellarakis, op. cit. (Chapter II, note 47), pp. 42-44.

59 ibid., p. 45

60 S.A. Semenov, Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear (USSR, 1958; 4th English impression, Moonraker Press, Wiltshire, 1976).

61 J. Sonnenfeld, 'Interpreting the Function of Primitive Implements', American Antiquity 28 no. 1 (1962), pp. 56-65.

62 Newcomer, op. cit. (Chapter II, note 13), p. 293.

63 ibid., pp. 294-95.

64 H. Camps-Fabrer and A. D'Anna, 'Fabrication expérimentale d'outils à partir de metapodes de mouton et de tibias de lapin', Colloque II, pp. 311-323, esp. 312-13, figs. 1, 2.

65 H. Sadek-Kooros, 'Intentional Fracturing of Bone: Description of Criteria', Archaeozoological Studies, ed. A.T. Clason (Amsterdam and Oxford, 1975), pp. 139-150.

66 H. Camps-Fabrer and A. D'Anna, _op. cit_. (note 64), pp. 313-14 figs. 3, 4.

67 F. Poplin, _op. cit_. (note 6), pp. 85-92, esp. figs. 7-11.

68 Jack Steinbring, 'The Manufacture and Use of Bone Defleshing Tools', _American Antiquity_ 31, no. 4 (1966), pp. 575-81.

69 _ibid_., p. 579

70 See N. de G. Davies _The Tombs of Menkheperrasonb, Amenmosé and another_, (_The Theban Tomb Series_, 5) (London, 1933), p. 9, 12 pl. VII (?tusks being carried); pls. XI, XII (? tusks being sawn). The identification is not wholly certain.

71 See Ritchie's comments quoted in note 34 above.

72 Michel Dauvois, 'Travail expérimental de l'ivoire: sculpture d'une statuette feminine', _Colloque_ II, pp. 269-73.

NOTES TO CHAPTER V

1 That is, the objects may indeed have been inlaid or attached to wooden furniture or boxes but as these have perished the precise function and disposition of the ivory decorations can only be deduced and not proven in the majority of cases. See also multiple compositions, Type 66 for some groups which can be reconstructed. In the case of seals, which we may compare with similar objects in stone, we have the seal impressions as partial evidence for the function of these items.

2 Thumb rests are marked with the sign 'X' on drawings of these tools. See figs. 48-9, 56.

3 According to Newcomer in the lecture cited (Chapter IV note 3) bone needles first appeared in the Solutrean.

4 Sememov, <u>op. cit</u>. (Chapter IV, note 59), p. 2.

5 <u>ibid</u>., p. 5

6 Newcomer has performed a number of experiments for purposes of determining function of tools. In the lecture cited above (Chapter IV, note 3) he discussed one case where a series of modern tools made and used by himself were sent to Laurence Keeley at Oxford. Using a high magnification binocular microscope Keeley was able to obtain the following results. Out of 15 examples he could identify the working end in 13 cases. In 11 cases he was able to identify the type of action, while the actual material worked was correctly noted in nine instances.

7 In the experiments mentioned above note 6, these problems of multiple action or use caused the most difficulty and accounted for the relatively high proportion of unidentified actions.

NOTES TO CHAPTER VI

1 Another point which might be stressed in a morphological typology is the type of bone used. Thus a distinction would be made between pointed implements made on whole sheep/goat metapodials; those made on whole sheep/goat tibiae and so on for various bones and species. This would mean that within our Type 1 we could further sub-divide into at least three types on kind of bone alone, before any attention was given to type of working end. Such a narrow morphological approach may be desirable in certain cases - a large sample of worked bone would be an essential starting point - but for our purposes a slightly more flexible approach has been adopted. In constructing a typology one must balance the difficulties caused by a proliferation of sub-types and types against the disadvantages of having too many 'exceptional' or 'atypical' examples within a type as defined. The introduction of a 'unclassifiable' or 'miscellaneous' heading can sometimes prove beneficial.

2 If, for example, we consider individual Type 12 tools made on split rib bones from two neighbouring areas we may learn that two groups of people were using similar types of tools made on similar bones, possibly for similar purposes. However, if we consider that there are limits to the way a given bone can be modified to produce a tool and that the species of animal are very likely to be similar in two adjoining areas then much of the value of such comparisons diminishes.

3 See: 'Débat général sur l'orientation et la désignation des différentes parties d'un object en os', in Colloque I p. 109-110 and H. Camps-Fabrer, 'Compte rendu des travaux de la commission de nomenclature sur l'industrie de l'os préhistorique', in Colloque II, p. 19 ff.

4 Poliochni is a notable exception. Even the Saliagos worked bone, so well presented, is illustrated working end downwards: J.D. Evans and A.C. Renfrew, Excavations at Saliagos near Antiparos (London, 1968), figs. 80, 81 pl. XLVIII.

5 see note 3 above.

6 See 'Débat général' in Colloque I (op. cit. note 3 above), p. 109.

7 In the OED 'butt' is defined as: 'Thicker end, esp. of tool or weapon.' I understand that Rosemary Payne in her work on neolithic bone tools of Greece and Anatolia uses the same term.

8 Nor is there general agreement about the application of these conventional terms. A further difficulty is understanding conventional terms, when not clearly defined, in foreign languages. For example the word 'aiguille' is frequently applied to objects which are clearly pins (our Type 11) and not needles (our Type 10). Whether there is a convention in French that the use of 'aiguille' is preferred to 'épingle' I cannot tell. When a piece is not illustrated it may prove impossible to determine what sort of object is being discussed.

9 Although in view of the difficulties described in note 8 above, the terms would still require careful definition.

10 Henriette Camps-Fabrer favours the universal typology for worked bone. As a step towards this she has devised a bone typology for 'French' Africa, chiefly the Sahara and Magreb from the palaeolithic to 'proto-historic' period. The excellent system of presentation and drawings should make it comprehensible to anyone specialising in worked bone. She does, however, use conventional terms to describe the objects. See: H. Camps-Fabrer, 'Industrie osseuse épipaleolithique et néolithique du Maghreb et du Sahara'. Fiches Typologiques Africaines, 6e et 7e cahiers, fiches 167-285. (Centre de recherches anthropologiques préhistoriques et ethnographiques, Algiers). ed. L. Balout and G. Camps.

11 This approach is favoured by Rosemary Payne in her studies of worked bone from the neolithic of Greece and Anatolia.

12 Lamb, p. 198, fig. 60.

13 ibid., p. 199.

14 The items published by Lamb have been given Mytilene Museum inventory numbers and most are on display. Those not on display are also roughly mounted and kept separate from the bulk of the worked bone which is in a variety of small boxes (e.g. wooden cigar boxes) very roughly sorted according to type. Whether this is Lamb's own sorting I cannot tell. The boxes are not labelled and were not all together in the Thermi apotheke at Mytilene. For further comments about my study session on the Thermi material see Chapter VIII n. 2.

15 Blegen I, pp. 28-29, fig. 126.

16 See Chapter II, p.   and note 25.

17 Blegen I, p. 97, fig. 219 cat.no. 36-168 from Troy Ib.

18 eg. Blegen I, Table 4, p. 47 (Troy I); Table 10, p. 216 (Troy II); Blegen II Table 25, pp. 302-03 a and b (EBA).

19 See further chapter IX. Attempts were made to study the Poliochni bone in the Myrina Museum, Limnos. Both the excavator, Professor L. Bernabò-Brea and the Director of the Italian School at Athens were pleased by my interest in this material and gave their permission for me to study it in 1978. A permit was not, however, granted by the Ministry of Culture. In 1979 during my visit to Lesbos, I learnt that study in Myrina is rarely possible, in spite of a new museum, due to lack of staff. For study to take place, the Ephor must be present. He is based in Mytilene and divides his time between Lesbos, Limnos and Chios.

20 Even so the number of Poliochni items is large. Some, however are placed in the catalogue only tentatively owing to difficulties of working with photogtaphs, however good they may be.

21 I am very grateful to Mr. Hood for his kind invitation to study his drawings and text of the Emborio bone. Ministry permission was also not obtained to study this material. The reasons are probably similar to those described in note 19. The Ephor, Mr. Tzerivakos did offer to let me see the Emborio bone on one of his visits to Chios. At the most I should have had one morning's work on the material which I felt would be insufficient when weighed against the cost of making a second trip to that part of the Aegean.

22 Mr. Hood also provides an excellent series of references to published material, not only of the Aegean area.

23 Banks, op. cit. (Chapter II, note 11).

24 See below and Appendix IVb. It is designed as a basis for a complete study of the Lerna bone industry which I shall prepare as soon as adequate information regarding contexts is available. This will be completely separate from the treatment of the bone in the individual volumes for the periods of the site. Some of that will be dealt with my Ms. Banks.

25 Banks' aims in her typology as for her dissertation as a whole are however different from those which would obtain in a site report. Her dissertation is basically a catalogue of all the small finds from the EHII-MH periods of Lerna and this may account for the lengthy descriptions of objects. It should also be remembered that Banks was not preparing a specialist study of worked bone. References to Banks' types are given in the footnotes to Chapter VII and her own catalogue numbers appear together with the Lerna inventory numbers in the Catalogue to this study.

26 Banks, op. cit. (Chapter II, note 11), plates 10-15.

27 The typology was established in July 1978 and revised slightly in July 1979. It will appear in the forthcoming volume in the Keos series: Keos III, House A, ed. E.V. Schofield and W.W. Cumner. See Appendix IVa.

28 Tubes, handles, hemisperical objects and toggles are all put under the heading 'Miscellaneous Types'. Even where a conventional term is retained (e.g. pins and needles) numerical designations are also provided.

29 All included in Banks' 'extremity-bone awls (c), (d)'. In the Aegean typology these are further sub-divided into Types 3-9 and some 14 unclassifiable pointed implements.

30 e.g. Lerna Type V (L5 287, L5 296) called 'Shuttles' by Banks. (Banks nos. 1121, 1122).

NOTES TO CHAPTER VII

1 There is one possible example from a neolithic context at Lerna of a Type 1 implement made from hare. The bronze age series of our Type 1 tools at Lerna are termed 'Extremity-bone awls (b)' by Banks. The type is defined in Banks, op. cit. (Chapter II, note 11), pp. 264-5 and are catalogued with the other 'extremity-bone awls (b) - (c)' p. 276 ff. It should be noted that for this and other types there is not an exact correspondence between our catalogued items and Banks'. That is, not all Lerna 'extremity-bone awls (b)' will be found under our Type 1 in the Catalogue. This is partly because our definitions vary from those of Banks and also because a number of tools which Banks places in a given type do not in fact correspond to her own definition of that type. For easy reference to Banks, her catalogue numbers are provided along with the Lerna inventory numbers in our Catalogue.

2 See also Chapter II note 20 and Appendix IIa.

3 Banks, op. cit. (Chapter II, note 11) and note 1 above. 'Extremity-bone awls (a)', p. 264 and 266 ff.

4 ibid., pp. 264-65 and 276 ff. 'Extremity-bone awls (c)'.

5 ibid., pp. 265-66 and 294 ff. 'Extremity-bone awls (d)'. During work on the Lerna bone in the Argos Museum I found that this large group of Banks' could readily be sorted into 7 or 8 types and sub-types based on size and kind of bone used, degree of modification and shape of working end. Some of these variations are reflected in our Catalogue where they appear under Type 5 a-b, 6, 7, 8 a-b and to a lesser extent Type 9. Others are unclassifiable (Type 14) according to our definition of any of these types made on portions of long bones.

6 Lerna examples found under Banks' 'Extremity-bone awls (d)'. (see note 5 above).

7 Banks, op. cit. (Chapter II, note 11), pp. 266 and 294 ff. 'Extremity-bone awls (e)'.

8 ibid., found under 'Extremity-bone awls (d)' (note 5 above).

9 ibid., in Banks' catalogue this type is not isolated. Some examples are found under her 'extremity-bone awls (a)', others under 'Pins'.

10 ibid., p. 420 ff. All Lerna examples are found under Banks' heading 'Needles'.

11 Dr. Imma Kilian, pers. comm., December 1980.

12 Banks, op. cit. (Chapter II, note 11), p. 370 ff. Most Lerna examples in our catalogue are found under Banks' 'Pins'. Her subdivisions are: (a) Plain (b) Decorated (c) Fragments of shafts not preserving heads (i.e. our 11e undiagnostic). She quite rightly recognises that many of the latter may belong to pointed implements and not pins. It therefore seems pointless to discuss the distribution of 'Pins (c)' in relation to the two other sub-types (e.g. p. 414).

13 Dr. Imma Kilian, pers. comm., November 1980. I am most grateful to Dr. Kilian for all her comments on pins which she has made available for use in this study. She has also very kindly provided me with a set of her figures of bone pins which will be included in her forthcoming study: Nadeln der frühhelladischen bis archaischen Zeit von der Peloponnes to appear as volume XIII, 10 of Prähistorische Bronzefunde. Although she will deal principally with the metal pins she says that 'owing to the scarcity of finds it is inevitable to consider the bone pins too, at least for EH-LH, to get an impression of the types available and development of forms'. Unfortunately for this study Dr. Kilian has not been able to examine the Lerna collection and must rely on Banks' line drawings (pers. comm. J.L. Caskey, July 1979).

14 Dr. Imma Kilian, pers. comm, November 1980 and February 1981. See also above Chapter IV, p. 127 for an unfinished example from the Citadel House.

15 Banks, op. cit. (Chapter II, note 11), p. 336 ff. 'Rib-bone awls' (not divided into sub-types), Her assertion on p. 340 that the type was 'well established in the Neolithic period at Lerna' is, I believe, unfounded. I could find only three examples of this type among the neolithic tools. Of course the four examples from mixed fill deposits might be either neolithic or Lerna III.

16 Not included in Banks whose study was confined to Lerna III-V.

17 Lerna examples are mostly from Banks 'Extremity-bone awls (c) and (d).'

18 Banks, op. cit. (Chapter II, note 11), p. 342 ff. 'Extremity-bone scraper/polishers (a)'. No distinction is made between working ends as in our 15 a, b.

19 I did not have my microscope with me during my study period at the Mytilene Museum. However, it is unlikely that it would have been of much assistance since a great many of the tools are encrusted and others have completely lost their patina, perhaps through cleaning agents.

20 Banks, op. cit. (Chapter II, note 11), p. 342 ff. 'Extremity-bone scraper/polishers (b) and (c).'

21 ibid., p. 357 ff. 'Rib-bone scraper/polishers (a).'

22 ibid., p. 357 ff. 'Rib-bone scraper/polishers (b).'

23 ibid., p. 357 ff. 'Rib-bone scraper/polishers (c).'

24 ibid., p. 466 ff. 'Horn awls'.

25 ibid., p. 324 ff. Included by Banks under 'Extremity-bone scraper/polishers (c)'. New Lerna typology (Appendix IVb) Type XIIb; Kea typology (Appendix IVa) Type IXa.

26 ibid., p. 342 ff. Included under 'extremity-bone scraper/ polishers'.

27 ibid., p. 446 ff. 'Knives'.

28 ibid., p. 443 ff. 'Combs'.

29 ibid., p. 437 ff. 'Tubes'. Two sub-types (a) being from sheep/goat tibiae with 'thread marks' at ends. Also pp. 441-42 for function.

30 ibid., p. 434 ff. 'Handles'. Banks also has doubts about the use of some of these implements for the purpose implied by the name. However, 37a: 14 (Banks 1130, L7 240) comes from a Lerna III floor deposit with several bronze awls. Banks thinks that some of these 'handles' may have served 'as nothing more than punches'. It is not clear what she means by 'punches'.

31 From the recent excavations at Phylakopi Professor Renfrew kindly informs me that a 'Handle, probably of mirror' has been found. The context is LHIIIb/c (Shrine, east). The dating is of course provisional. I have not seen the piece or illustrations of it so am unable to determine whether it should be placed with our Type 44.

32 Banks, op. cit. (Chapter II, note 11), p. 429 ff. 'Whorls (a)'.

33 ibid., p. 429 ff. 'Whorls (b)'.

34 See Chapter II, note 13.

35 Banks, op. cit. p. 454 ff. 'Toggles.' (Two sub-types based on presence of a perforation).

36 I have discussed this matter with Helen-Hughes Brock and her impression that bone and ivory were little used especially in the Mycenaean period for beads, corresponds with my own.

37 Pre.Mac. pp. 87, 202, fig. 66j. Said to be EBA.

38 Symeonoglou, op. cit. (Chapter II, note 83) figs. 259-60.

39 I have not handled any of these figurines myself so descriptions are based on published sources and observation in the cases of the Iraklion Museum. The ivory figurine of Cycladic type from Archanes is not catalogued. See: I. Sakellarakis, Praktika (1972) p. 336 ff, pl. 285a.

40 See Iv. Myc. pp. 45, 49-54.

NOTES TO CHAPTER VIII

1 The sites selected for study were of course limited by those for which permission could be obtained and which provided an adequate collection of bone or ivory remains for analysis. On the whole access to unpublished material from sites excavated by the foreign schools of archaeology in Greece has been the easiest to study. Published material is usually the most difficult to obtain Ministry permission to study since it involves extra duties for museum staff whereas the unpublished material is generally held in excavation storerooms. In spite of these problems I have been fortunate enough to handle material from all main periods and areas of the Aegean, barring Northern Greece.

2 See also Chapter VI note 14. Ministry of Culture permission was obtained to study this material during 1979 but the amount of time I was able to spend, with the Thermi collection was limited to two and one-half mornings work, owing to the busy schedule of the Ephor, Mr. Tzerivakos. Difficulties were caused by the fact that I was only able to study material from 2-3 boxes (note 14, Chapter VI) at a time; nor is it certain that I saw all the Thermi material. The published items, most of which are on display, are nicely mounted on a velvet-covered cards but these could not be removed from the mounting. Nonetheless, I am grateful to Mr. Tzerivakos for his help and to one of the museum guards who showed me the location of the site of Thermi. It has now been covered in.

3 It is very strange that the bone cards could not be located. Lamb's original notebooks and all the other inventory cards appear to be complete. Even the original correspondence between Lamb and Miss Bate regarding the fauna and other specialists' reports are preserved at the BSA. However, in the index-card box labelled 'bone inventory cards' were the stone inventory cards.

4 Some adjustments were made by Lamb; for example she says that the objects from area Θ and H are omitted owing to the steep slope of the strata. (Lamb, p. 197).

5 See note 2 above. It is quite likely that other examples of Lamb type 2 were all together in a box which I did not see.

6 Lamb states (p. 197) that 'exceptional quantities lay in the deposits between 5 and 3.5 m'. Her table shows that 34 examples in all were recovered (excepting Θ and H). I was able to find about 27 objects of this type in the Mytilene Museum.

7 Whether the published and extant pieces of antler are the only examples recovered is not indicated. In her report Miss Bate notes that most of the antler (of which there was little) was from the proximal end of shed antler (see Chapter II and Chapter II note 34).

8 I have handled few Lerna small finds other than the bone, but working from Banks' catalogue I must admit that very rarely does the associated material give any indication of function of bone tools or the rooms in which they were found. On Banks' identification of a 'bone artisan's workshop' in House D-BS see Chapter IV p. 166 and note 45.

9 Work on the Lerna final publication is proceeding with the Graves volume (ed. E.T. Blackburn and J.L. Caskey) completed and pending final editing. Other volumes will deal with Lerna period III (J.L. Caskey and M.H. Wiencke), Lerna IV (E.C. Banks) and Lerna V (C. Zerner). E.C. Banks and others will be preparing the small find catalogues for inclusion in most of these volumes.

10 Banks, _op. cit_. (Chapter II, note 11), p. 690-91.

11 Professor Caskey has confirmed my views on the effect of the type of deposits excavated for Lerna III on our picture of the bone industry. We discussed the matter at some length in July 1979 and only the chief points are summarised here and below. For a brief account of the Lerna evidence see: J.L. Caskey, 'The Early Helladic Period in the Argolid', _Hesperia_ 39 (1960), pp. 285-303; p. 293 for Lerna III.

12 Banks, _op. cit_. (Chapter II, note 11), p. 691; p. 328 ff for 'extremity-bone awls (d)', especially p. 329 for use of surface colour to link tools from Lerna III contexts (uncontaminated) with a neolithic date (also Chapter III note 16). For rib-bone awls see p. 336 ff and Chapter VII note 15.

13 _ibid_., p. 691.

14 _ibid_., p. 686.

15 _ibid_., p. 698. By contrast Banks says of Lerna III: 'Bronze was at home in their culture, while bone and stone were used sparingly. This confirms the observation that the inhabitants of Lerna III had left the Stone Age far behind.' (p. 697).

16 _ibid_., p. 692.

17 _ibid_., p. 407-08 for Banks' interpretation of the Lerna IV examples of pins with simple heads (her pins (b)). She does not however accept the dating for either pins (a) or (b), that is our 11a, 11b-c in Lerna III contexts (p. 405).

18 _ibid_., p. 419. To my knowledge Banks did not examine any of her comparative material at first hand, and I have handled few MH pins myself.

19 Also perhaps related is 11c: 29 from Lerna IVd.

20 See comparative material on introductory pages of Type 11 in the catalogue. I was able to examine the Lefkandi inventory cards held at the British School at Athens in 1978 and noted the occurrence of the hammer-headed pin at that time. Further information about this pin and its context must of course await the final publication of the site but I am grateful to Mr. M. Popham and Mr. Hugh Sackett for permission to mention its existence in this study.

21 See introductory pages to Type 11 in the Catalogue for references in Childe, Dawn of European Civilisation (6th ed. London, 1957).

22 J.L. Caskey, pers. comm. These contexts are designated Lerna VI. In all there are some 25-30 bone objects (including antler) from Lerna VI. I have prepared comments on these which will appear in the forthcoming Graves volume in the Lerna series (above note 9).

23 Nearly all the bone, ivory and antler objects from the site are still housed in the excavation apotheke, near the site of Ayia Irini. There I also had access to the inventory cards and pottery books which provide the preliminary dating for many of the objects. The House A volume (Chapter VI note 27) is in final stages of editing and consequently all House A objects from periods VI and VII have final 'dates'. This also applies to a smaller group of objects from Kea V contexts which are included in J.L. Davis's account of that period on the site. A few of the objects including the comb, ivory pyxis, and helmet plaques from House A have been taken to the Khora Museum where they are being stored until the Museum can be opened.

24 ANM 206 Poursat, cat.no. 210 pl. XVIII p. 59. The decoration of the Kea piece seems a little rough by comparison. To my knowledge Poursat has not seen this piece; nor did I until 1979 as it is housed in the Khora Museum and not Kea apotheke. As a result, only a basic description of the piece appears in the catalogue of objects for House A which was completed in December 1978. Further investigations regarding the origins of this piece will be made before I prepare the continuous account of the Kea bone and ivory industry for publication.

25 This assessment is based only on a comparison of the published illustrations of the Mycenae and Kakovatos pieces with my own photographs of the Kea piece. See also Chapter VII p. 252.

26 This account is based only on the workers' debris and small items such as Type 56 inlays housed in the Stratigraphical Museum at Knossos. Other pieces from the Royal Road excavations, including the human figures are on diaplay in the Iraklion Museum.

27 For example the figurines mentioned above (Type 64a: 4).

28 Lord William Taylour, Well Built Mycenae (introductory fascicle) (forthcoming, 1981). I was able to read this in MSS in June 1981. This summarises the principal phases of the site, the major architectural aspects and provides a history of the excavation. Most of the information presented below on the location of finds and their contexts comes from site records and information kindly supplied by Dr. E.B. French.

29 Taylour, (forthcoming).

30 A few might be Hellenistic; only a handful of bone objects come from pure Hellenistic contexts.

31 Taylour (forthcoming) and Helen Hughes-Brock, pers. comm. who is publishing the jewellery from the site. The minute beads include some which might be bone, although identification is not positive. Their average diametres are 0.002 - 0.003. They are not catalogued here.

32 As suggested by Taylour (forthcoming).

33 Taylour (forthcoming).

34 Also from this room, not catalogued is a bronze rivet with bits of ivory adhering to it. It probably belongs to the pronged objects.

35 Taylour (forthcoming).

36 These two objects are stored in the main part of the Nauplion Museum not in the Mycenae apotheke. I was unable to see them in either 1978 or 1979; consequently the discussion is based on photographs, inventory information and published accounts.

37 Hood, op. cit. (Chapter II, note 79), p. 126.

38 Iv. Myc. pp. 53, 233 but cf. now Barnett's review in JHS 100 (1980), p. 286: 'True, it resembles vaguely the 'head of Yarim-lim' (so-called) found at Atchana: but it does not strike me at all as a genuinely Oriental piece.'

39 Hood, op. cit. (Chapter II, note 79), pp. 126 and 102 fig. 83.

40 According to Dr. E.B. French.

41 Although not so indicated in Taylour (forthcoming). Apart from the four ivory objects the objects in the group fall under the heading of 'jewellery' and will be considered by Helen Hughes-Brock in her fascicle on this material from the site.

NOTES TO CHAPTER IX

1 See report on the faunal remains by M.R. Jarman in P.M. Warren, Myrtos. An Early Bronze Age Settlement in Crete (Oxford, 1972), p. 318 ff. Only four pieces of worked bone are reported. From Pyrgos (Myrtos-Pyrgos) nearby there is a similar dearth of worked bone. About 10 pieces were recovered, virtually all in a bad state of preservation. I was able to examine these with kind permission of the excavator, Prof. Gerald Cadogan. They are housed in the Stratigraphical Museum, Knossos.

2 A very rough estimate would be about 2000 objects from the campaigns directed by Professor J.D. Evans (1957-60 and 1969-70). I have looked at some of these in the Stratigraphical Museum. For the items published already see the comparative sections on the introductory pages to the catalogue.

3 That is, whether one adheres to the view that the pre-palatial period was one of long, continuous development (e.g. Branigan op. cit. Chapter II, note 66, p. 204) or agrees with Cherry's recent interpretation of a major transformation in Minoan society toward the end of the pre-palatial period. J.F. Cherry, 'Evolution, Revolution, and the Rise of Complex Society in Minoan Crete' paper presented to the Cambridge Colloquium on Minoan Society, 30 March - 2 April 1981 to be published in Minoan Society, ed. L.F. Nixon, O.H. Krzyszkowska (Bristol Classical Press, 1982).

4 Krzyszkowska, op. cit. (Chapter IV note 24).

5 ibid., and Chapter II, p.44 f.

6 I am grateful to Professor P.M. Warren for his permission to study the bone and ivory remains from his excavations on the Royal Road, 1970-72 and for providing me with stratigraphical information. The pieces are housed in the Stratigraphical Museum, Knossos. One major gap for this period is the fact that no worked bone was published from Harriet Boyd Hawes' excavations at Gournia.

7 The 'bracelets' may be some kind of moulding pieces. See under Type 67: 4, 5 for references.

8 Dr. Imma Kilian, pers. comm., December 1980.

9 There is, for example, the small arm reported from Chrysolakkos (64a: 6) and possibly the leg from Lerna (64a: 5) if it is indeed Cretan manufacture.

10 The Palaikastro plaque seems certainly LMIb and Hood, (op. cit. Chapter II, note 79), p. 121 thinks the South House plaque should also be dated to LMI. Poursat seems to regard it as LMII-IIIa.

11 Hood, op. cit. p. 122; Iv. Myc. p. 178.

12 Of course only if it could be shown that such carvings were produced by Minoan workshops during the LMI period.

13 It is unlikely that a continuous study of the Lerna bone industry such as Professor Caskey has asked me to prepare could be undertaken before the final publication of the site is completed.

14 Attempts were made to locate the Asea bone in 1978. According to Dr. Robin Haag, Director of the Swedish Institute in Athens, the worked bone was believed to be in Tegea Museum along with other material from the site. This was also the feeling of the excavator Dr. Holmberg. The material had originally been taken to Nauplion Museum after excavation, but some time later, possibly when the new Tegea Museum opened, it was moved there. Certainly there seemed little evidence that the bone was still in Nauplion. A Ministry of Culture permit was issued for study at Tegea but on arrival at the museum it proved impossible to confirm existence of the objects there or elsewhere. It is always possible that the worked bone was lost during the war - the fate of the Asine bone and ivory originally in Nauplion (pers. comm. Robin Haag).

15 Being prepared by Rosemary Payne. The detailed work of Sebastian Payne on the faunal remains from that site will also ensure that all worked bone is isolated for study. I am grateful to both Rosemary and Sebastian Payne for showing me some of the Franchthi material in the Leonardon, Nauplion during May and June 1979 and for many fruitful discussions about bone and worked bone.

16 See above Chapter VIII note 12 and VII note 15 for this type at Lerna.

17 See J.L. Caskey, op. cit. (Chapter VIII, note 11); R.J. Howell, 'The Origins of Middle Helladic Culture' in Bronze Age Migrations, ed. R.A. Crossland and A. Birchall (London, 1973) and O.T.P.K. Dickinson, Origins of Mycenaean Civilisation (SIMA XLIX) (Goteborg, 1977), chapter II.

18 But see above Chapter VIII, note 17.

19 Dickinsön, op. cit. (note 17), p. 39 ff for sequence of Graves in Circles A and B.

20 ibid., p. 43; S. Piggott, Ancient Europe (Edinburgh, 1965), p. 134 believes the Grave Iota mounts and those from Bush Barrow show the 'earliest datable contact is in Wessex' (between the High Barbarian cultures and the Aegean. Renfrew has however pointed out that the dating for Circle B is not early enough for Wessex and mentions the fact that David Clarke believed that Beaker decoration may have provided a source for the decoration on the Bush Barrow mountings. See: A.C. Renfrew, 'Wessex without Mycenae', BSA 63 (1968), p. 284.

21 Prosymna, p. 461, fig. 217. Fragments only, said to be vessel or vase made from ivory and bronze. Dated to LHII

22 Comb: ANM 211, Poursat no. 310, pl. XVIII, p. 61 'peigne de coiffure'; pyxis: ANM 206, Poursat no. 210, pl. XVIII, p. 59.

23 Iv. Myc. p. 26, 'pyxides à paroi mince'.

24 For dating I have generally followed Poursat in Iv. Myc. pp. 11-14 ('Table de Provenance').

25 Regarding the Palaikastro combs and Katsambas pyxis Poursat says: 'Les ivoires crétois nous donnent ainsi, pour un certain nombre de formes ou de motifs, les exemples plus anciens que nous connaissons actuellement.' In his view, this does not, however indicate a Cretan origin for Mycenaean ivory carving. He goes on to say: 'Les ivoires du MR I B que nous avons cités ont sans aucun doute été crées sous l'influence des ateliers ou des artistes mycéniens.' (Iv. Myc. p. 166).

26 Iv. Myc. p. 249-51.

27 One apparently new and unusual form is the 'spindle' and 'spindle whorl' of which several examples are reported in ivory from Perati, decorated with incised circles and dots (70: 54-57).

28 For Phylakopi see 1b: 11. The Kythera tools cannot be classified, although they all seem to be pointed implements. At least one (from an EMII-MMIa context) may be made from a rib bone. J.N. Coldstream and G.L. Huxley, Kythera (London, 1972), p. 205 ff; fig. 59, 60, 61; pl. 59.

30 J.E. Coleman, Keos I: Kephala (Princeton, 1977).

31 Shell, especially spondylus, might also have served for certain blunt implements. On Kea there were several toothed objects similar to the rough bone combs (Type 33), denticulated along one edge. (NC).

32 Gamble, op. cit. (Chapter II, note 6), p. 747.

33 See illustrations in Praktika (1976) B', pl. 192.

34 Above Chapter VIII, p. 280 and note 24.

35 For this study material earlier than Troy I is dealt with only in the 'comparative' sections on the introductory pages to types in the Catalogue.

36 See for example p. 430 nos. 559-580 and 431 nos. 581-87 in H. Schliemann, Ilios (reprinted Arno Press, New York, 1976). Perhaps one of the greatest misfortunes for the study of worked bone was the adoption of photography for illustration. Many reproduced in pre-war publications are of too poor quality and too small to be informative. Even now many excavators seem to prefer photographs to drawings. Shortage of illustrators trained to draw worked bone and ivory might be part of the problem. I understand that very few people can be found to make drawings of unworked bone (pers. comm. Sebastian Payne).

37 But see above Chapter VII, note 1. for a possible example from Lerna neolithic and Chapter VI, p. 198 and note 17 for the use of hare bones at Troy.